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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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London,
15th June, 1916. E 431

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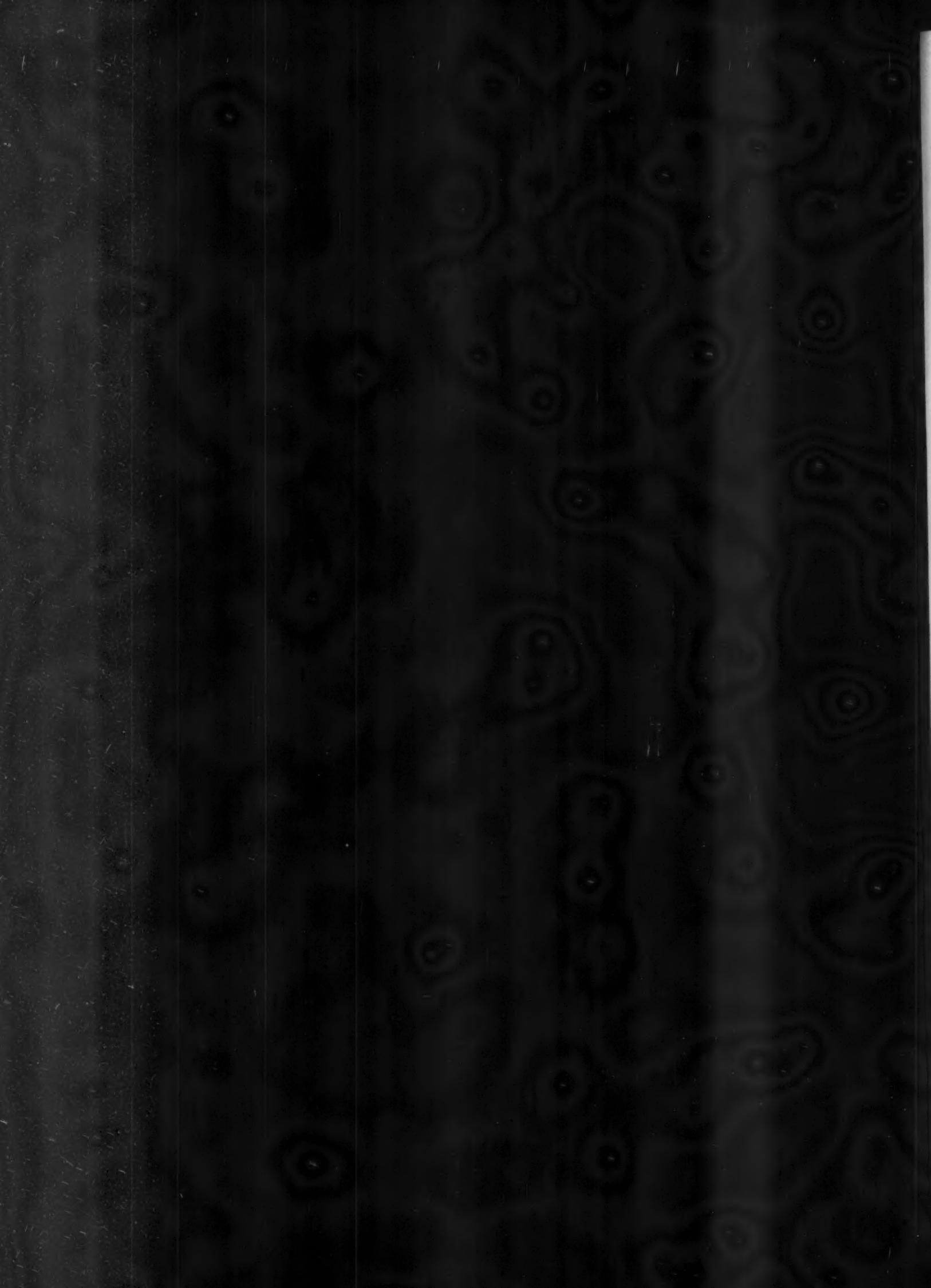


BRACKET-LOADS ON COLUMNS OF CONSTANT CROSS-SECTION.

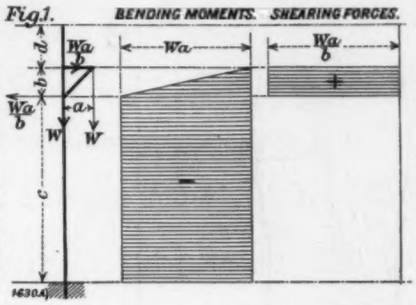
By WILLIAM DUNN, Assoc. Inst. C.E., F.R.I.B.A.

A LOAD W, applied to a column by means of a bracket, is generally treated as producing in the column (1) a compression W applied axially, plus (2) a bending moment equal to the load W multiplied by the distance from the point of application on the bracket to the axis of the column.

An example will be found in the report of the Royal Institute of British Architects' Committee on Reinforced Concrete (1911), page 19; the column illustrated being one fixed at the base and free at the top. The deflection of the column under load produces a small increase in the lever-arm of the load; but this, being very small in relation to the lever-arm, is disregarded. In what follows, the effect of any such change of shape will also be disregarded

The end conditions have as much effect on columns with bracket loads as on beams under ordinary loads, but this does not appear to be considered in any of the well-known text-books. The following short study is intended to supply that omission.

Columns Fixed at Base, Free at Top.—This case, analogous to that of the cantilever beam, may be dismissed very briefly, reference being made to Fig. 1.



The load W, whose lever-arm is a, produces in the column, at the top of the bracket, a horizontal force of $\frac{W a}{b}$; at the base of the bracket a similar force, but acting in the reverse direction; and a force W acting downwards. The lines of action of the forces $\frac{W a}{b}$ are, of course, the centres of tension and compression in the bracket; b is the distance between these.

The resulting bending moments and shearing forces are shown in Fig. 1. From these, and the direct axial compression W below the bracket, we can find the stresses in the column.

Column Hinged at Top and Bottom, Supported at Base.—The reactions and forces which W produces in this column and its supports are shown in Fig. 2. These are:—

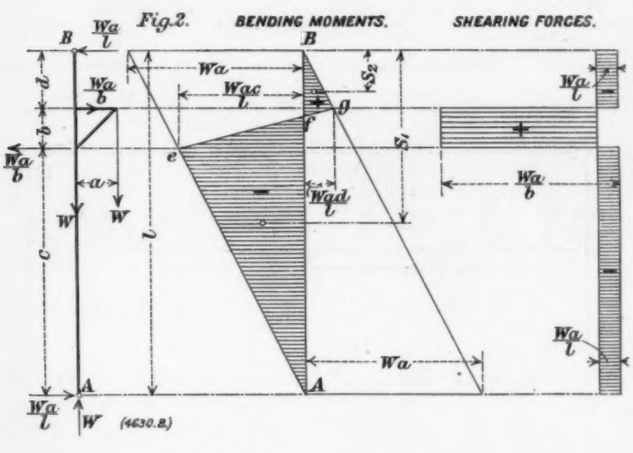
1. At top and botton of bracket, horizontal forces each $= \frac{W a}{b}$ as before.

2. Direct compression in column from base of bracket to base of column of W as before.

3. Horizontal reactions at top and bottom of column, each $= \frac{W a}{l}$, but acting in opposite directions.

4. Vertical reaction at base of column of W.

The bending moments are readily derived from the reactions, but a simple semi-graphical method is as follows:—On the diagram of bending moments mark off at top and at base lengths equal to Wa, the bending moment on the bracket; connect the ends of these lengths (which are set off on opposite sides of A B, the vertical axis of the column and closing line of the bending-moment diagram) with A and B in the manner shown in Fig. 2; join the intersections of the lines last drawn with the lines of action of $\frac{W a}{b}$, by the line $e f g$. Then $A e f g$ B is the diagram of bending moments; it forms two triangles A $e f$ and B $g f$, which, being on opposite sides of the closing line, indicate moments of different sign. On the figure, the first is marked − and the second +



As before, the part of the column below the bracket has also a direct compression W.

The diagram of shearing is also shown.

Compare the different moments and shearing forces which arise in this case, and note that the maximum bending moment on the column is always less than Wa, the bending moment on the bracket. It varies with the position of the bracket on the height of the column, and with the depth of the bracket, as well as with the bending moment Wa on the bracket.

Column Fixed at Base, Hinged at Top.—Now consider the same column, but with one end—say the lower end—rigidly fixed, and the other—the top—hinged (Fig. 3).

The bending moments are as shown in Fig. 2, but with an additional moment M_A at A, the fixed end, as in Fig. 3. As there can be no moment at B, the hinged end, this additional moment will vary along the column from M_A at A to zero at B, as shown by the triangle A h B. The resulting actual moments in the columns, appearing as the sum or difference, will be as shown by the hatched areas $+ A h i$, $- i e j$, $+ j g$ B. (We shall call those moments which produce tension on the bracket side of the column +, and those producing tension on the opposite side −)

For the determination of the end moment M_A, we have to consider how the column will bend under load. At A, the column is supposed rigidly fixed, so that the tangent line there remains constant, and in line with B, which point B is held in position laterally by a horizontal force.

According to the theory of elasticity the deflection at B from the tangent at A is given by the equation—

$$\delta = \frac{1}{E I}\int_A^B M x\, dx,$$

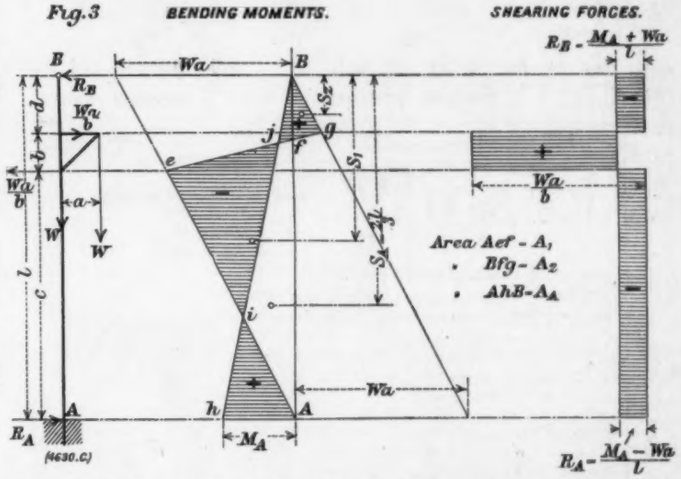
x being measured from B, the free end. As B remains in line with the tangent at A, we have $\delta = 0$

The column being of constant cross-section, I is constant, and E may also be taken as constant; so that we may write—

$$\int_A^B M x\, dx = 0 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In the case in hand the method of the calculus may be replaced by the simpler plan of finding the areas of each constituent part of the bending-moment diagram, and multiplying by the distance of its geometric centre (centre of gravity) from the origin at B.

The bending-moment diagram may be considered as formed of three triangular areas, A $e f$, B $f g$, and A h B. Let us call these areas A_1, A_2, and A_A respectively; then A_1 and A_2 can be measured from the diagram, drawn as from a column with free ends; and as $A_A = \frac{M_A l}{2}$, we have only to find M_A.



The distances of the geometric centres of each of these areas can also be measured from the diagram. Call these S_1, S_2, and S_A. The last is, of course, equal to $\frac{2l}{3}$.

The equation $\int_A^B M x\, dx = 0$ is satisfied when

$$A_A S_A - A_1 S_1 + A_2 S_2 = 0,$$

from which we get—

$$A_A = \frac{3 (A_1 S_1 - A_2 S_2)}{2 l}.$$

Also, since $A_A = \frac{M_A l}{2}$,

$$M_A = \frac{3 (A_1 S_1 - A_2 S_2)}{l^2} \quad . \quad . \quad (2)$$

Plotting the bending-moment diagram as for the column with free ends, and adding M_A of the above value, we get the final bending-moment diagram as shown by the hatched areas.

Fig. 3 also shows the shearing forces.

Column Fixed at Both Ends (see Fig. 5).—There will now be moments at both ends of the column, and two equations to be satisfied—*i.e.*:—

$$\text{Total deflection } \delta = \frac{1}{E I}\int_A^B M x\, dx = 0 \quad . \quad (3)$$

$$\text{Total change of angle} = \frac{1}{E I}\int_A^B M\, dx = 0 \quad . \quad (4)$$

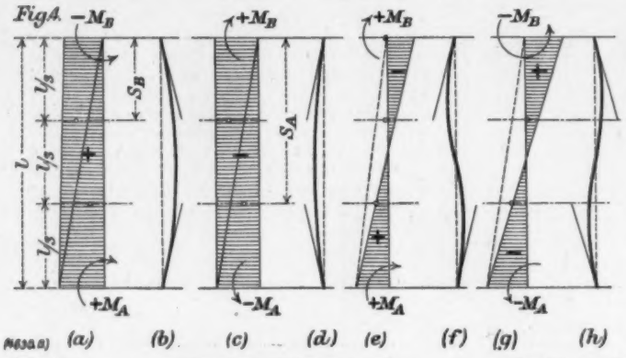
The origin of x will be taken at B, and E I assumed constant, as before.

To the bending moments on a column with hinged ends we must add the effects produced by the end moments M_A and M_B.

Attention to the signs of these moments is necessary.

Figs. 4 (*a*) to (*f*) show the effects of end moments on a bar. In (*a*) and (*c*) the end moments are of different sign, producing in the bar no contra-flexure, and accordingly moments on the bar of one sign only. We have shown moments tending to bend the bar to the right hand as plus moments. In (*e*) and (*g*) the end moments are of the same sign, producing contra-flexure in the bar, and moments of different sign in the bar itself.

According to the signs found, we have to add to the bending-moment diagram of the column with



hinged ends, moments as in (*a*) (*c*) (*e*) or (*g*). The final moments must satisfy equations (3) and (4).

The method of moment areas multiplied by distances from origin at B to geometric centres of areas will again be used. Let A_1, A_2, A_A, A_B be the moment areas, and S_1, S_2, S_A and S_B the distances. Then the equations (3) and (4) will be satisfied when

$$A_A S_A - A_1 S_1 + A_2 S_2 - A_B S_B = 0.$$
$$A_A - A_1 + A_2 - A_B = 0.$$

These equations give

$$A_A = \frac{A_1 S_1 - A_2 S_2 - A_1 S_B + A_2 S_B}{S_A - S_B}$$
$$= \frac{3 A_1 (S_1 - S_B) + 3 A_2 (S_B - S_2)}{l};$$

and as

$$A_A = \frac{M_A l}{2},$$

we get finally

$$M_A = \frac{6 A_1 (S_1 - S_B) + 6 A_2 (S_B - S_2)}{l^2} \quad . \quad (5)$$

Similarly,

$$A_B = \frac{A_1 S_1 - A_2 S_2 - A_1 S_A + A_2 S_A}{S_A - S_B}$$

and

$$M_B = \frac{6 A_1 (S_1 - S_A) + 6 A_2 (S_A - S_2)}{l^2} \quad . \quad (6)$$

A numerical example will make the working clear.

Column with ends rigidly fixed; length l of 9 ft.; bracket-load W of 10 tons, acting with a lever-arm a of 1 ft.; distances b, 1 ft.; c, 6.5 ft.; d, 1.5 to (see Fig. 5)

Having set off the height of the column A B to any convenient scale, and drawn horizontal lines through A and B, and through the lines of tension and compression in the bracket, distant d and $d + b$ from the top, choose any convenient scale for moments and set off, the lengths $Wa = 10$ ft., tons at top and bottom on opposite sides of A B, joining the extremities with A and B, and drawing $e\,f\,g$ as before. The closing line $h\,k$ is to be found from equations (5) and (6)

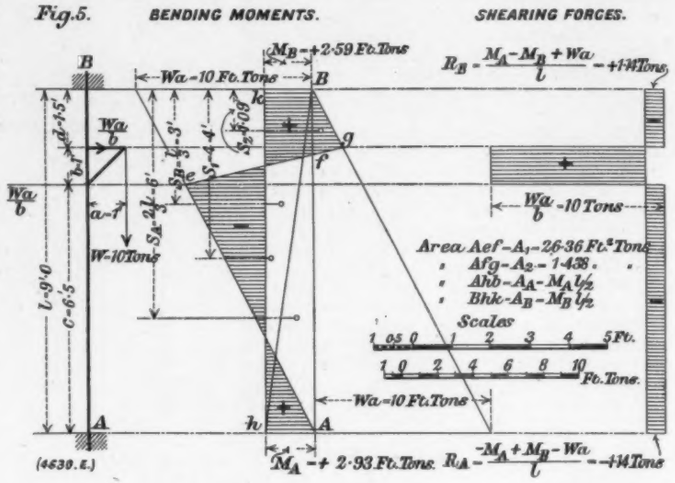


Fig.5.
BENDING MOMENTS.
SHEARING FORCES.
M_B = + 2·59 Ft.Tons
$R_B = \frac{M_A - M_B + Wa}{l}$ = +1·14 Tons
Wa = 10 Ft.Tons
Wa/b = 10 Tons
W = 10 Tons
Area Aef = A_1 = 26·36 Ft.²Tons
Afg = A_2 = 1·438 "
Ahb = $A_A - M_A l/2$
Bhk = $A_B - M_B l/2$
Scales
1 0·5 0 1 2 3 4 5 Ft.
1 0 2 4 6 8 10 Ft.Tons.
M_A = + 2·93 Ft.Tons.
$R_A = \frac{-M_A + M_B - Wa}{l}$ = -1·14 Tons
(4630.E.)

$$M_A = \frac{6 \times 26.36\,(4.4 - 3) + 6 \times 1.438\,(3 - 1.09)}{81}$$
$$= 2.93 \text{ ft.-tons}$$
$$M_B = \frac{6 \times 26.36\,(4.4 - 6) + 6 \times 1.438\,(6 - 1.09)}{81}$$
$$= -2.59 \text{ ft.-tons.}$$

This gives us + moments in the column as in Fig. 4 (*a*). Set off A h = M_A and B k = M_B as in Fig. 5, and draw the closing line $h\,k$; the bending moments in the column are shown by the hatched areas.

The shearing forces are obtained from the loads and end moments as usual, and are also marked on the diagram.

If the bracket is nearer the centre of the column, we get a different result. In Fig. 6 we have a similar column and bracket-load, but the bracket is at the centre of the column, so that $d = c = 4$ ft.

Proceeding as before, we find from (5) and (6)

$$M_A = M_B = + 2.46.$$

The bending moments in the column arising from these are of the type shown in Fig. (4 *e*), and being plotted in Fig. 6, give us the hatched areas as the moments in the column.

Graphical Method for Columns with any Method of Fixing.—A graphical method (of German origin) similar to that used for continuous beams will now be given.* Reference will be made to Fig. 7.

Set off the axis of the column A B, and the lines of action of the horizontal forces at top and bottom of column and of bracket. Set off A A^1 and

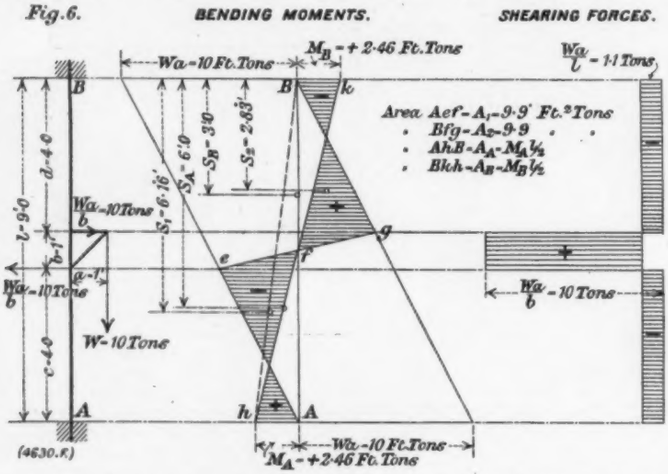
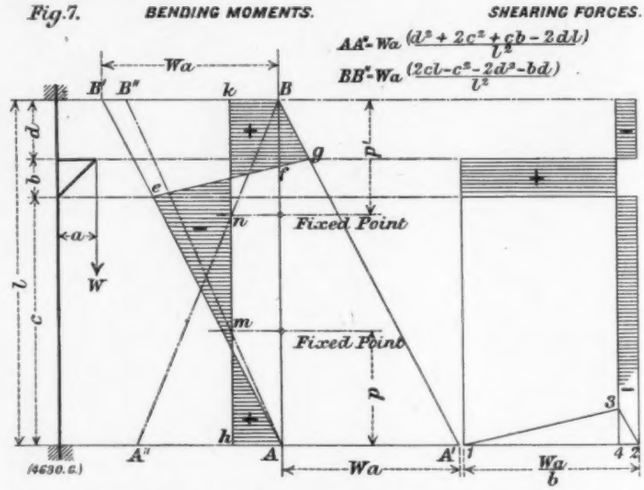


Fig.6.
BENDING MOMENTS.
SHEARING FORCES.
M_B = + 2·46 Ft.Tons
Wa = 10 Ft.Tons
Wa/l = 1·1 Tons
Area Aef = A_1 = 9·9 Ft.²Tons
Bfg = A_2 = 9·9 "
Ahb = $A_A - M_A l/2$
Bhk = $A_B - M_B l/2$
Wa/b = 10 Tons
W = 10 Tons
M_A = + 2·46 Ft.Tons
(4630.E)



$$AA'' = Wa\,\frac{(d^2 + 2c^2 + cb - 2dl)}{l^2},$$

and B B″ equal to

$$Wa\,\frac{(2cl - c^2 - 2d^2 - bd)}{l^2}.$$

Draw A″ B and B″ A (these are the "cross lines"). Set off the lengths p and p^1 the distances from A and B of the "fixed points." For end fully fixed each of these equals $\frac{l}{3}$. Draw horizontal lines through these "fixed points" and mark the intersections with B″ A as m, and with A″ B as n. Through m and n, the intersections, draw the straight line $k\,n\,m\,h$; this is the closing line of the bending-moment diagram.

If one end of the column is hinged—say the top end—the distance p^1 from B to the fixed point is zero, and the closing line would be drawn through B and m. Similarly, if the bottom end were hinged, the distance p would be zero, and the closing line would be drawn through A and n.

If the column were one of a series of continuous columns of similar sections and heights, held horizontally at each floor, but not otherwise fixed, the distances p and p^1 would be taken at 0.211 l.

* For graphical methods for continuous beams, see lectures on "Reinforced Concrete," by W. Dunn. (Published by the University of London Press.)

For the shearing-force diagram, set off $1\,2 = \frac{W a}{b}$ and draw 1 3 parallel to $e\,g$, and 2 3 parallel A e. Draw 3 4 parallel to the closing line h K. Then 2 4 is the shear at A and B; 1 4 is the shear between the top and bottom of the bracket.

To the moments formed we must add not only the direct axial compression W below the bracket, but any other direct load on the column.

HOBBING HIGH PRIME-NUMBER SPUR-GEARS WITHOUT SPECIAL MECHANISM.

By WILL. O. WYNNE.

THE production of high prime-number spur-gears is not a very pressing need, and the following investigations are due, not to necessity, but to the usual clause in almost any description of a modern gear-hobbing machine . . . "with the exception of prime numbers."

Although there may be little, if any, demand for high prime-number spur-gears, I make no apology for introducing the subject, as, in the first place, the study of the problem will, I think, be found to be interesting, and, secondly, a machine which is limited to 430 teeth, with the exception of prime numbers, compares rather unfavourably with one which will deal with any number up to 1000. The advantage also of this as a selling point need not be enlarged upon.

It would be unfair to say that the prime number has beaten the designer. The prime number, until recently, has never been seriously attacked, and, like many other problems which have been looked upon as insoluble, its downfall is brought about in the simplest possible manner. It is to the indivisibility or impossibility of factorising the prime number that its immunity from attack by the hobbing-machine designer must be attributed; but an examination of the methods employed in dealing with the problem by the milling-machine specialist at once reveals the point at which the prime number is most vulnerable.

Although the prime number cannot be factorised, it can be separated into two numbers, one of which is less than 10, and the other divisible by 10, the sum of the two forming the prime number. It is in this way that the milling-machine designer has overcome the difficulty—viz., by differential and compound indexing. Of course, nothing in the nature of a dividing-plate can be adopted in the hobbing-machine; but the addition and subtraction of continuous motions are easily dealt with by a differential gear; therefore, apparently, it is upon this gear that we must depend to enable us to terminate finally the long reign of the prime number. Although high prime-number spur-gears may not be in general demand, the introduction of reduction gearing for turbines has rendered the production of high prime-number helical gears almost imperative, in order to avoid synchronism and to distribute wear. In this connection it may be remembered that the firm of Wm. Muir and Co., Limited, of Manchester, have recently patented and applied to their turbine gear-hobbing machines a special mechanism which enables the machine to produce spur, helical and spiral gears of any number of teeth up to 1000, at any angle (helical gears being cut automatically with absolutely the same angle) and at any rate of feed—a comprehensive series of conditions with which it is impossible to comply in the methods about to be discussed.

I do not propose at the moment to examine any particular gear-hobbing machine, but merely to illustrate how a machine could be designed which would have no superfluous mechanism over and above that found on machines fitted with a differential gear, but which at the same time will cut high prime-number spur-gears.

One solution to the difficulty can be very simply stated as follows:—

In the ordinary gear-hobbing machine, fitted with a differential gear, one set of gears controls the dividing, and another the spiral lead.

There is no difficulty whatever in hobbing a spiral gear having a prime number of teeth on a machine as above, using the dividing-gears only, the differential gears controlling the spiral lead at the moment being inoperative. Now utilise the spiralling change-gears to *take off* the spiral which is being put on by the dividing-gears, leaving a spur-wheel with a prime number of teeth.

Fig. 1 shows a diagrammatic sketch of a gear-hobbing machine without a differential gear; A is the hob, B the change-gears, C the worm driving the table, and D the change-gears driving the feed-screw which actuates the hob-slide.

Fig. 2 shows a left-hand hob operating upon a right-hand gear.

Let N = number of teeth to be cut.
L = lead of gear in inches.
F = feed in inches of hob-slide per revolution of table.
R = ratio of machine, or revolutions of hob per revolution of table, with equal dividing-gears at B.

During the down feed L″ of the hob, the work

Fig.1.

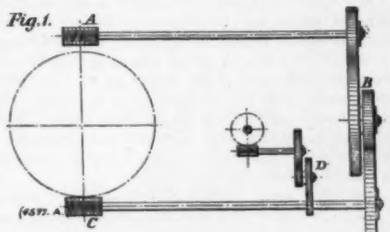


Fig.2.

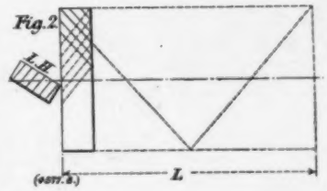
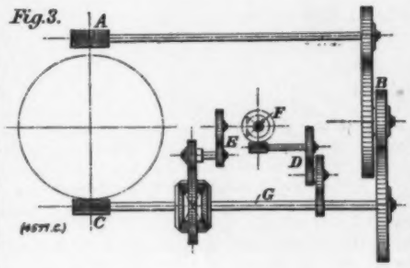


Fig.3.



will make $\frac{L}{F}$ revolutions. During that time, if a spur-wheel were being produced, the hob would make $\frac{L}{F} \times N$ revolutions. In this spiral gear, however, the teeth themselves make one circuit of the gear in L″; therefore the number of revolutions of the hob must be increased or decreased by N during the down feed L″, the increase or decrease being dependent upon whether the hands of the gear and hob are opposite or similar respectively.

Therefore

$$\text{Revs. of hob} = N\left(\frac{L}{F} \mp 1\right).$$

$$\frac{\text{Revs. of hob}}{\text{Revs. of work}} = \frac{N\left(\frac{L}{F} \mp 1\right)}{\frac{L}{F}},$$

and change-gears required at

$$B = \frac{N\left(\frac{L}{F} \mp 1\right)}{R\,\frac{L}{F}}.$$

As the object in view, finally, is to cut a spur-gear, the lead L″ is used in order to facilitate the elimination of the prime number N. Thus a lead L″ must now be selected which, when divided by the feed, will enable the quotient to be divisible by the prime number N; but this quotient, when increased or decreased by 1, must factorise into factors each less than 100. Bearing this in mind, and examining the change-gear ratio, it will be found that this ratio can now be factorised into factors each less than 100, so that change-gears can now be mounted up at B, Fig. 1, which will produce a spiral wheel with N teeth and L″ lead.

It is necessary now to examine a machine fitted with a differential gear for producing the angle on the teeth. The differential gear is sometimes fitted to the table-drive, and sometimes in the hob-drive, the relative merits of which, from the ordinary gear-hobbing standpoint, it is not my intention here to discuss; but an expression of the ratios for each machine reveals an interesting point. Fig. 3 illustrates diagrammatically a machine fitted with the differential gear in the drive to the table. The shaft G drives through feed-change gears D through worm and wheel to the feed-screw F, this screw driving through spiralling change-gears E the differential motion, so correcting the speed of the worm driving the work to produce the angle on the teeth.

Assume the machine to be geared up as described to cut a prime number of teeth N with spiral lead L″, the spiralling gears E being stationary; then revolutions of hob during down feed L″ is, as before, $N\left(\frac{L}{F} \mp 1\right)$, and revolutions of work $\frac{L}{F}$. Revolutions of G and C, while differential gear is stationary, $= T\,\frac{L}{F}$; where T = number of teeth in table worm-wheel, assuming single lead worm. It is necessary now, if the spiral lead is to be taken from the work by accelerating or retarding the work, to take from or add to C, T revolutions during $\frac{T\,L}{F}$ revolutions of G. Thus, ratio of reduction between G and C

$$= \frac{T\frac{L}{F}}{T} = \frac{L}{F};$$

but the lowest factor of $\frac{L}{F}$ is the prime number N; therefore a prime number gear of N teeth would be required in E, which, of course, is precisely the thing which must be avoided. Apparently, therefore, our purpose cannot be served by a machine as shown with the differential gear in the table drive.

Referring now to Fig. 4, page 592, this illustrates a machine fitted with a differential gear in the hob-drive. The shaft G drives through feed-change gears D through worm and wheel to the feed-screw F which drives through spiralling change-wheels E the differential gear, so correcting the speed of the hob in order to produce the angle on the teeth.

When cutting a spiral wheel as described, with the change-gears at B arranged so as to produce N teeth with L″ lead, the spiralling gears being inoperative, during the down feed L″ the members G and H each make a certain number of revolutions, the lowest factor of each being the same prime number N. It is required to take from A, N revolutions during this number of revolutions of G, the lowest factor of which is the prime number N; therefore no prime-number gears are required in the gearing from G to the differential gear, rendering it possible to gear up by ordinary wheels. Referring to the statement:—

$$\text{Revs. of work} = \frac{L}{F}.$$

$$\text{Ratio of reduction between table and hob} = \frac{\frac{L}{F}}{N};$$

but $\frac{L}{F}$ has already been arranged to be divisible by N, therefore it is an easy matter to gear up at E for the required reduction.

Taking an actual example, let N = 617. Referring to Fig. 4, worm-wheel in table 60 T. Equal change-gears at E cut a lead per tooth of $\frac{1}{N}$ in.—that is, while the feed-screw, driven by change-gears (or gear-box) D, moves the hob-slide $\frac{1}{10}$ in. equal gears to the differential gear impart one additional revolution to A (or take off one, as the case may be). Stating the quantity,

$$\text{Change-gears required} = \frac{N\left(\frac{L}{F} \mp 1\right)}{R\,\frac{L}{F}},$$

we get change-wheels $= \dfrac{617\left(\dfrac{L}{F} \mp 1\right)}{60\,\dfrac{L}{F}}$.

Now $\frac{L}{F}$ must be a multiple of 617, and at the same time must, when reduced by 1, factorise into numbers less than 100; $617 \times 3 = 1851$, $1851 - 1$ is easily factorised. Assuming feed $= \frac{1}{20}$ in., $L = 1851 \div 20 = 92.55$ in.

The statement now becomes

$$\text{Change-wheels} = \frac{617\left(\dfrac{92.55}{1/20} - 1\right)}{60 \times \dfrac{92.55}{1/20}}$$

$$= \frac{617 \times 1850}{60 \times 1851} = \frac{185}{18} = \frac{74}{30} \times \frac{100}{24}.$$

These gears mounted up at B will produce a spiral gear of 617 teeth having a spiral lead of 92.55 in.

Equal gears at E cut $\frac{1}{617}$ in. lead per tooth; lead per tooth on spiral gear which would be cut by dividing change-wheels, as above, $= \dfrac{92.55}{617} = 0.15$ in.

Therefore change-wheels required at

$$E = \frac{0.15}{0.0625} = \frac{60}{25}.$$

These gears mounted up at E will *take off* the lead 92.55 in. from the gear which would be cut by the gears at B, leaving a spur-wheel with 617 teeth.

In order now to check the calculations, it is only necessary to assume any number of revolutions of the table, and find the corresponding revolutions of the hob, and if the result,

$$\frac{\text{Revs. of hob}}{\text{Revs. of work}} = \frac{617}{1},$$

then our object is attained.

Assume feed-screw to be $\frac{1}{8}$-in. pitch, then half-a-revolution of feed-screw must impart one revolution to hob A. Let differential gear be driven by equal spur-gears. This mechanism has an adverse purchase of $2 - 1$, therefore equal wheels at E impart two revolutions to A per revolution of feed-screw. Feed is to be $\frac{1}{20}$ in. for one revolution of table $= 60$ revolutions of shaft G. Assume worm-wheel on feed-screw to have 15 T, then ratio of gearing at D

$$= \frac{1}{10} = \frac{20}{50} \times \frac{15}{60}.$$

The gears at E could also be calculated in the following way:—Revolutions of G during down feed $L'' = 60\,\frac{L}{F}$; revolutions required to be added to or subtracted from A during $60 \times \frac{L}{F}$ revolutions of G $= N$; therefore ratio of gearing between G and A $= \dfrac{60\,L}{N\,F}$, and change gears at $E = \dfrac{60\,L \times R_1}{N\,F}$, where R_1 = ratio between G and A with equal gears at E. Thus we get

$$R_1 = \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{2}{1} = \frac{1}{75},$$

and change gears at E

$$= \frac{60}{617} \times \frac{92.55}{\frac{1}{20}} \times \frac{1}{75} \times \frac{60}{25}.$$

Having now fixed upon all the gearing ratios, assume table to make 20 revolutions.

$$\text{Then revs. of H} = 20 \times \frac{60}{1} \times \frac{100}{24} \times \frac{74}{30} = 12{,}333.3.$$

$$\text{Revs. of feed-screw} = 20 \times \frac{60}{1} \times \frac{20}{50} \times \frac{\frac{15}{60}}{3} \times \frac{1}{15} = 8.$$

Pitch of screw $= \frac{1}{8}$ in., therefore feed $= 1$ in. in 20 revolutions of table, feed per revolution $= \frac{1}{20}$ in.

Revolutions of feed-screw $= 8$, therefore additional revolutions imparted to A through gears E and differential gear

$$= 8 \times \frac{25}{60} \times \frac{2}{1} = 6.66.$$

We subtracted from the revolutions of the hob in order to produce the spiral, therefore we must now add this number of revolutions to the speed of shaft H in order to take off the spiral.

$$\text{Revs. of hob} = 12{,}333.3 + 6.66 = 12{,}340.0.$$
$$\text{Revs. of work} = 20.$$
$$\text{Teeth produced} = \frac{12{,}340}{20} = 617 \text{ T}.$$

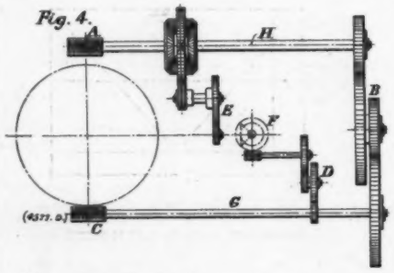
It will be seen, then, that high prime-number spur-wheels can be produced on an ordinary gear-hobbing machine without special gearing. There is nothing in the mechanism discussed which is not common to most gear-hobbing machines.

The foregoing may be interesting in the respect that the development of this idea is based upon the known possibility of hobbing spiral gears, having prime numbers of teeth, without a differential gear; but by relegating for a moment that knowledge into the background, and approaching the problem from an altogether different standpoint, a still more simple solution presents itself.

Any prime number up to 1000 is within 5 of a number which will factorise into factors less than 100; therefore if the driving gears can be arranged so as to cut within 5 of the required number, and the differential gear used to put on or take off up to 5 revolutions per revolution of the work, then any number up to 1000 can be dealt with. This is without doubt the real common-sense solution to the problem, and, moreover, as is usually the case, is much simpler.

Referring again to Fig. 4, following the gearing from the worm driving the table through feed-gears D to the screw in the hob-slide, then through

Fig. 4.



spiralling gears E to the differential gears and so to A, it is obvious that there is no reason whatever why the gears E cannot be arranged of ratios which will impart 1, 2, 3, 4, or 5 additional revolutions to A, or take away that number of revolutions from A, for 1 revolution of the table, independently altogether of the dividing gears B. Taking again the case of 617 teeth, the object now, however, being to arrange the dividing-gears to cut 620 teeth, and by means of the differential gear to take off from the hob 3 revolutions per revolution of the table. The spiral lead does not now enter into the question.

$$\text{Ratio of change gears} = \frac{60}{620} = \frac{24}{80} \times \frac{20}{62}.$$

$$\text{Feed gears to screw as already used} = \frac{20}{50} \times \frac{15}{60}.$$

Assume equal wheels at E. Let table make 1 revolution, then revolutions of A with dividing gears B and shaft H stationary

$$= 1 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{2}{1} = 0.8 \text{ revolution}.$$

Thus equal wheels at E will impart 0.8 additional revolution to A per revolution of table; but it is necessary to subtract three revolutions; therefore, an adverse purchase of gears at E of $\dfrac{3}{0.8} = \dfrac{90}{24}$ must be introduced, taking care that the direction of rotation of the differential is such as will subtract from the motion of H, this, of course, being controlled, if necessary, by an intermediate at E.

Dividing gears

$$= \frac{24}{62} \times \frac{20}{80},$$

and spiralling gears adverse $\dfrac{90}{24}$.

Again, let the table make 20 revolutions.

$$\text{Revs. of H} = 20 \times \frac{60}{1} \times \frac{80}{24} \times \frac{62}{20} = 12{,}400.$$

Revolutions subtracted from H by differential gear in 20 revolutions of table

$$= 20 \times \frac{60}{1} \times \frac{20}{50} \times \frac{15}{60} \times \frac{1}{15} \times \frac{90}{24} \times \frac{2}{1} = 60.$$

Total revs. of A $= 12{,}400 - 60 = 12{,}340$.

Number of revolutions of hob per revolution of work

$$= \frac{12{,}340}{20} = 617.$$

It must be pointed out that although in the ordinary hobbing of spur-gears the feed does not enter into the calculations, and could, if occasion demanded, be changed during the cutting of the gear, this is not the case in the two methods just discussed. This arises from the fact that, although the feed itself bears no important relation to the motions which are operating to produce the spur-gear, the gears which lead up to the feed-screw form part of the train, which is, in the first case, taking off the spiral from the prime-number gear, and, in the second, taking from the hob three revolutions during the one revolution of the table. Thus the feed in either case could not be changed during cutting. It could be arranged to change the feed during cutting by designing the machine slightly differently; but this, of course, is at present irrelevant. However, the impossibility of changing the feed during cutting need not militate against the adoption of the arrangement, first, because this is seldom necessary, and, secondly, because any machine not fitted with a differential gear, of which there are many, is hampered in precisely the same way when cutting a helical gear.

In conclusion, although I am not prepared to be dogmatic on the point, it appears that—paradoxical as it may seem—less gearing will be necessary on a machine arranged as described, in order to produce the usual range, including prime numbers, than has been previously found necessary to cover the ordinary range, exclusive of prime numbers, as in the arrangement discussed the dividing-gears need only be mounted up to cut multiples of 10, the gearing controlling the differential gear producing the intermediate numbers.

COMBINED RAILWAY AND HIGHWAY SCHERZER ROLLING-LIFT BRIDGE.

THERE has just been completed on one of the important cross-country main lines of the Great Central Railway system, as part of an important deviation and widening scheme, a bridge over one of the English rivers (which, for military reasons, cannot be named), having a Scherzer rolling-lift opening span weighing 2900 tons, the largest in this country, if not, indeed, in the world. The bridge spans one of the important navigable rivers, on which there is a considerable amount of traffic, and replaces a bridge, having a swing opening span, built in 1861. When the improvement of the railway line was under discussion, there was, as is usually the case under such circumstances, a strong public desire not only that the span should be greatly increased as compared with that of the old bridge, in order to improve the navigable channel, but that greater facility for traffic across the river should be provided. Mr. J. B. Ball, M. Inst. C.E., the engineer of the railway company, under whose supervision the designs were prepared and the whole of the work carried out, made a very careful study of the situation, and of the conditions which the local authorities desired to have fulfilled, and ultimately recommended the adoption of the Scherzer roller lift for the opening span, with provision for a double line of railway, and for a broad road bridge, with footpaths parallel to the railway track. The Scherzer system, now well known, having been described repeatedly in ENGINEERING, commended itself not only as a complete structure suitable for the situation, but for the convenience with which it could be built without interfering with the river traffic.

The existing swing bridge, which is already on a central pier in the river, provides two navigable channels, each 60 ft. in width, whereas the lifting span of the new bridge gives a clear waterway 150 ft. wide, equal to the two openings of the old bridge together with the central dolphin and piers, as illustrated in Fig. 1, Plate LI. This is a very great gain, because the navigation is difficult, first, on account of the very rapid current (sometimes

RAILWAY AND HIGHWAY SCHERZER ROLLER-LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

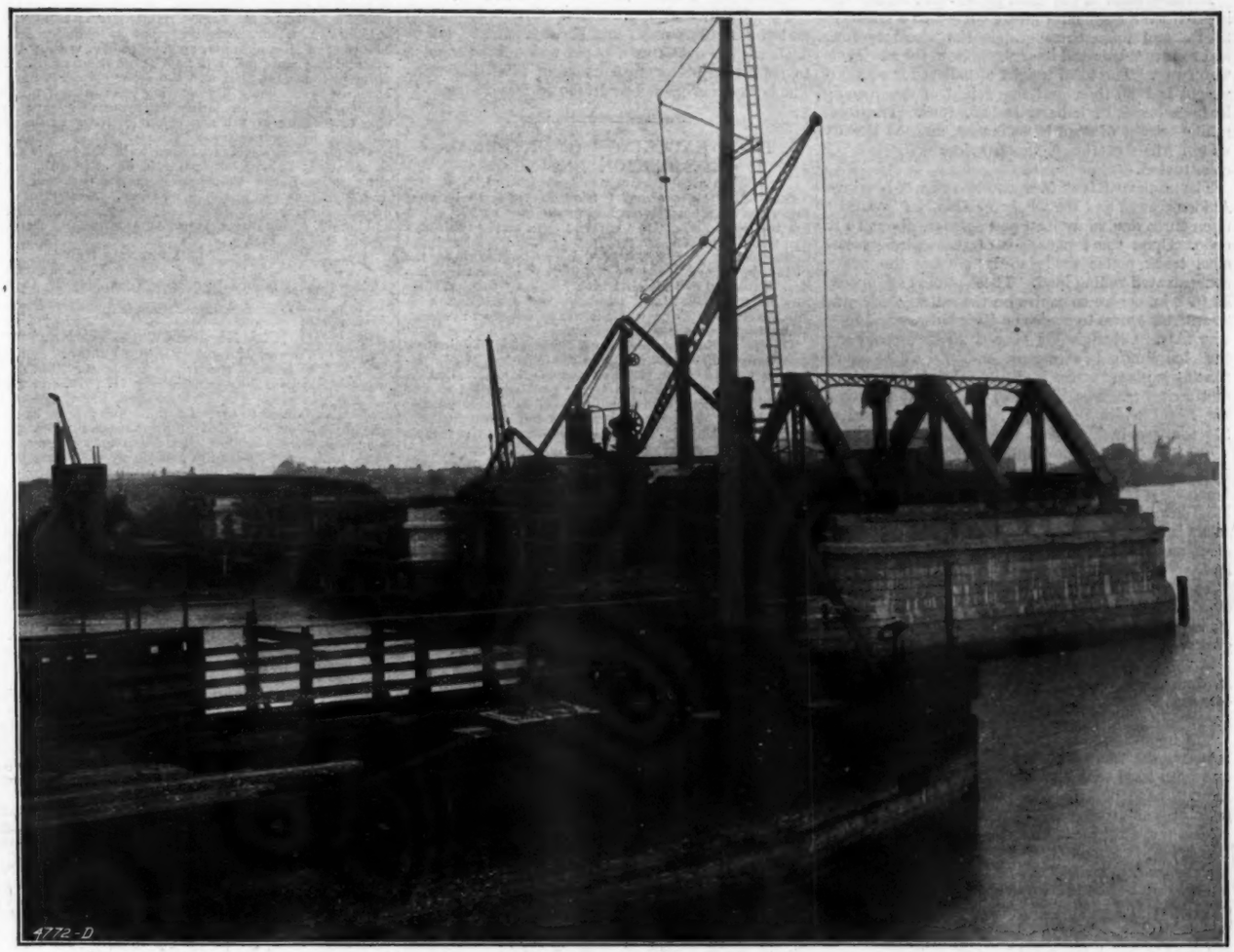


FIG. 4. PIER AND ABUTMENT FOR WEST FIXED SPAN COMPLETED, MAY 8, 1914.

about 9 knots), and because of the bend in the river. The roller-lift principle enabled the constructional steel work of the opening span to be built in a vertical position, leaving the river between the abutment and the pier in the river free for the passage of river craft. As ships with masts are only a small proportion of the total traffic, the rail and road level was made higher than in the case of the old bridge, so that the span will only require to be opened occasionally, and even then not always for the full extent of the lift.

The provision of a public roadway alongside the railway, together with new road approaches on each side of the river, constitutes a great public advantage. Convincing evidence of this is afforded by the fact that the old bridge was a railway bridge only, and there was no means for vehicular traffic crossing the river within a distance of 15 miles. It will thus be recognised that the bridge is not only important from the design and construction points of view, but also from the standpoint of public convenience in the district in which it is located. Thus the illustrations which we publish on Plate LI. and on the present page and page 600 are interesting.

The new bridge is built only a few yards distant from the old bridge, which will subsequently be removed. It was constructed by Sir William Arrol and Co., Limited, of Glasgow, whose chairman, Mr. A. S. Biggart, took an active interest in the work. As shown on the elevational view of the bridge, Fig. 1, on Plate LI., it consists of two fixed river spans and two land spans, in addition to the opening span, and the view along the railway track, Fig. 2, also on Plate LI., shows that it is of the "through" type. There is seen to the left the fence dividing the roadway from the railway. Fig. 3, Plate LI., is a view from the other end of the bridge, showing the counterbalance of the roller-lift.

The roadway has a clear width of 16 ft. between the kerbs, and the footway a width of 5 ft. The two fixed spans each have a clear opening between the piers of about 126 ft.; the opening span of the rolling-lift type provides, as already stated, a clear waterway of 150 ft. in width; a track span, upon which the opening leaf rolls backwards in opening, with a length of 40 ft. centres of piers; and a land span of 70 ft. The floor of the bridge is made with flat steel plating, supported upon cross-girders and stringers. On the railway side the rails are supported upon creosoted Baltic redwood timbers bedded on asphalt concrete and secured to the floor plating by continuous strips. Suitable guard-channels are provided to the rail-tracks. On the roadway side the road is formed of rock asphalt upon a concrete bed for the fixed spans. On the opening span the roadway is constructed of dowelled Jarrah wood blocks upon a continuous bed of pitch-pine timbers, suitably cambered to fall to the side channels. The footways are made of timber planking.

The two fixed approach spans, illustrated on Fig. 1, Plate LI., are each 135 ft. centre to centre of bearings. The floor system of each span is carried by three main girders of the Pratt type, 18 ft. 8 in. deep over flanges, and divided into ten panels, the two centre panels being counterbraced. The main girders are spaced 29 ft. 3 in. centre to centre on the railway side, and 24 ft. 3 in. centre to centre on the roadway and footway side. Cross portals and diagonal windbracing are placed at the top flanges of the main girders. Cross-girders are spaced 13 ft. 6 in. apart, and carry longitudinal stringers and the floor.

The opening span is 160½ ft. from centre of bearing at nose to centre of gudgeon pin, measured horizontally. The floor system is carried by three main girders of the "Warren" type, with a maximum depth of 36 ft., tapering to 18 ft. deep at the nose end, and divided into eight panels. These main girders are spaced 29 ft. 3 in. centre to centre on the railway side, and 24 ft. 3 in. centre to centre on the roadway and footway side. Cross portals and substantial diagonal bracing are placed at the top boom level, and carried back to the ballast-box. The cross-girders are spaced 19 ft. 8½ in. apart, and carry the longitudinal stringers and floor. The ends of the three main girders are carried past the gudgeon pins to a ballast-box, which has a length of 55 ft., a depth of 35½ ft., an average width of about 13 ft., and a capacity of 24,780 cub. ft.

This ballast-box, which is well shown in Fig. 3, on Plate LI., contains sufficient grout-concrete ballast to counterbalance the whole weight of the opening leaf about the gudgeon pins.

Between each of the main girders and ballast-box is provided a segmental girder curved to a radius of 28 ft., and upon these girders the whole opening leaf rolls upwards and backwards from the navigable waterway. The total weight of ballast for counterweight is 1780 tons, and the weight of the opening leaf, exclusive of ballast, is 1120 tons. The total rolling weight of span is 2900 tons, and, as already stated, the structure is the heaviest of its class yet constructed.

The track span is 40 ft. centre to centre of bearings. A floor system and the whole opening leaf is carried upon three double webbed plate girders about 10 ft. deep. Upon the top flanges of these girders, cast steel track plates are placed to carry the heavy concentrated rolling load. These girders are spaced 29 ft. 3 in. centre to centre on the railway side, and 24 ft. 3 in. centre to centre on the roadway and footway side. Cross-girders spaced 20 ft. apart carry the longitudinal stringers and floor. Diagonal bracing is placed at the underside of the cross-girders and stringers. The cast-steel track plates have a net lineal width of 50¼ in., and carry a load of 57¼ tons per inch width.

To the sides of the outer track girders braced frameworks are attached to form rack supports. Upon these rack supports two steel racks about 40 ft. long are provided. The distance between these racks is 58 ft. 8 in. centre to centre. This allows a clear passage the full over-all width of the opening leaf.

The main girders for the land span are 72 ft. over all in length. The floor system is carried by three plate girders about 7 ft. 6 in. deep. These girders are spaced 29 ft. 3 in. centre to centre on the railway side, and 24 ft. 3 in. centre to centre on the roadway side. Cross girders are spaced at 11 ft. 4 in. centres, and carry the longitudinal stringers and floor.

The operating gear is placed on the opening span between the main gudgeon pins and ballast-box, and on a level with the gudgeon pin. Two electric motors, each of 115 horse-power, gear up, with a train of gears, to the main gudgeon pins at the outer girders; upon these pins the main pinions are keyed. The bridge is accurately balanced, but with a slight preponderance to the nose end in order to prevent hammering on the bearings. This brings the centre of gravity of the whole opening leaf slightly in advance of the centre of the gudgeon pins. The rotation of the main gudgeon pins with their gear causes the pins to travel along the fixed racks, and roll the opening leaf backward or forward on the segmental curved girder over the track girder. This allows the bridge to open, and leave the navigable waterway altogether clear, or allows the bridge to be shut and free for traffic over the bridge. Electric gear of sufficient power to open or close the bridge against a 20-lb. wind is provided, and the time for either operation takes three minutes. Auxiliary petrol gear and also hand gear is provided for emergencies. At the nose end of the opening leaf a double locking bolt is placed, electrically operated from the operator's cabin. One air-buffer is also placed in a central position at the nose. Two hydro-pneumatic buffers are fixed to the main girders of the land span, and, by contact with the ballast-box, bring the bridge to rest as it reaches the full open position.

The east and west abutments are carried upon timber piled foundations. The abutments are faced with dressed grey granite and blue brick, and backed with concrete. Four river pier caissons were sunk under compressed air, and founded upon firm red clay, at a maximum depth of about 70 ft. below highest water level. The piers are faced with dressed grey granite, and backed with concrete. Each pier is carried upon a permanent steel caisson, the largest of which is 94 ft. long, 20 ft. wide, and 32 ft. deep. This pier is placed between the opening and track spans.

Work was commenced at the site in December, 1912, and preliminary tests of the bridge were made during January, 1916. The Board of Trade tests were made in May. The load on the railway side was made up of four of the heaviest Great Central Railway locomotives, two on each track, arranged head to head to get the maximum local load, and on the roadway side two 15-ton traction engines, each drawing a heavy lorry loaded with rails.

The design and construction of this important undertaking, known as the Keadly Bridge, will be dealt with in detail in a paper which it is proposed to read before the Institution of Civil Engineers. The bridge was opened for traffic on May 21 last.

THE "KNOCKING" OF INTERNAL-COMBUSTION ENGINES.

To the Editor of Engineering.

Sir,—A few years ago I tried to ventilate in your paper the question "Why does an engine 'knock'?" A few replies came in, but none shed light on the subject. I had called attention to the fact that, since I use close-fitting pistons (ringless), it is obviously impossible for the piston to "knock" because of a loose fit within the cylinder. Extended experiments with "jacket" temperatures ranging from below zero to above 650 deg. Fahr. have left the ringless piston where it was at the start: capable of holding pressure without leakage.

Of late experiments have been made using illuminating gas (water gas) as fuel, to avoid the existence of two unknown quantities at one and the same time. Certain engine characteristics were in the past regarded as due to faults. These experiments have, however, cleared up matters. With a hot cylinder a too rich a fuel will cause "knocking;" it matters not whether the fuel be illuminating gas, kerosene, or gas oil, &c.

For example, when an engine has been under load long enough to have a jacket temperature of about 350 deg. Fahr., kerosene (lamp oil) will burn without smoke at the exhaust or fouling of the sparking-plugs. A closing of the magneto switch will cause the cessation of "firing" instantly, indicating that the points of the plugs do not overheat; but leaving the throttle wide open with the engine still spinning, a very rich mixture is drawn into the cylinder, with the result that the engine will commence to "knock," or prematurely and automatically ignite. The engine will not keep running, however, since it cools down very rapidly, so that but a few such "knocks" or "poundings" will be heard.

When using illuminating gas for fuel no "knocks" can be produced with the "jacket" at, say, 200 deg. Fahr., while with temperatures of 500 to 650 deg. Fahr. and higher a too rich a mixture will cause "knocking." Seemingly "knocking" goes together with premature ignition, which is of an automatic character.

What, according to the latest theory, causes pounding in steam heating-pipes when pipes are cold and the steam turned on? Is it not quite possible that the noise produced has its cause practically identical in both cases? In both cases a dense vapour is being raised in temperature at a rapid rate (in the case of steam a heavy cloud of condensed steam must travel before the ingoing steam, such cloud being caused by the cold pipes which the steam enters).

Closely connected with the foregoing the following facts may be considered:—With jacket temperatures at 300 deg. Fahr to 350 deg. Fahr. the engine will run excellently on kerosene, whether the ignition is by "coil" or "magneto;" but once stopped for any reason at all, the engine cannot be restarted except on gasoline. Thus, when proper fuel mixtures are used and the engine stopped by the magneto short-circuiting switch, if an immediate attempt at starting is made, one or two faint "coughs" are produced. If the attempt at starting is made after waiting a minute, not even that is forthcoming. Once the engine has made a single cycle on gasoline, it will take kerosene perfectly (with jacket temperatures of at least 300 deg. Fahr.).

The engine in hand is a conventional 4-in. by 5-in. four-cylinder automobile engine, with inlet valves in cylinder heads and exhaust valves at the side (a design least suited for high-temperature operation); it has conventional coil and magneto ignition (high tension), also a conventional carburettor, and "ringless pistons" in cast iron are used. The lubricating oil is cooled in a small radiator by a fan, and is forced into the cylinders at a pressure of about 3 lb. per sq. in. by a small gear-pump. The lubrication is on a circulating system; the splash is discontinued.

The ignition situation as here reported would indicate that the amount of "heat release" (to use that expression for lack of a better one) of either coil or conventional magneto is not sufficient to ignite the charge. This can be even proven as a fact beyond doubt. Three years ago I started an engine "on the crank"—*i.e.*, by hand—on kerosene, the source of electric current being four dry cells, high-tension ignition; but I used a special "igniter," which is, in fact, the old "shot channel" once universally used, but later condemned. The "igniter" differs from the other, however, in that its "charge" is under control, never harbouring spent gases.

The sparking-plug situation has also appeared in a new light. Although operating with "jacket" temperatures of 650 deg. Fahr. and more, plug troubles are here unknown. During early experiments plugs were operated even at cherry red. Sparking-plugs, therefore, do not suffer from heat, but from heat alternations—that is to say, the enamel or glaze of the porcelain or stone of the plug, when subjected to the cooling of the incoming charge, and in turn then subjected to the high heat of the explosion, will, much like a steel spring, die of fatigue, and that from the alternate stresses. In this instance here, when the engine temperature has been brought to very great heights, no cracked plug has ever been experienced. As already stated, the points do not overheat, as proved by prompt stoppage of the engine upon closing the magneto short-circuiting switch.

Experiments have shown that plugs located in the path of the incoming gases will foul in a day when using kerosene for fuel, but will not foul at all when placed out of reach of the incoming gases. It is interesting to know that the plugs of the engine referred to have always a light-brown colour, excepting that of cylinder No. 2. The plug of that cylinder, strange to say, is snow-white most of the time (as if it had never been used). The difference between that and the other cylinders may be observed when using illuminating gas; a rich mixture is then apparent. In earlier experiments I have been able to produce at will any colour of the plug desired; this in conjunction with the "igniter."

The plug design which I found to be the best is about as follows: The central point is enclosed by parallel outer points; the porcelain is of the petticoat type, with ¼-in. hole and about $\frac{1}{16}$ in. thick. A sparking-plug manufacturer brought his whole array of plugs to test and found, to his dismay, that another plug of his competitor was the better.

Yours very truly,
P. G. Tismer.

Rose Bank, Staten Island, New York, May 26, 1916.

"OIL-ENGINE NOMENCLATURE."

To the Editor of Engineering.

Sir,—I have read the article under the above title appearing in your issue of February 11, 1916, and whilst I admit the writer's evident practical knowledge of his subject, in justice to myself I must ask you to be good enough to allow me a little of your space to place other facts before your readers that I can only assume were either unknown or not fully realised by the writer of the article in question.

He speaks of attempts that have been made lately, at home and abroad, to take away from Dr. Diesel the credit of inventing the Diesel cycle. British engineers have for some time objected that the names "Diesel," "Semi-Diesel" &c., are incorrectly applied, and my object in writing this letter is to show you that the cycle on which all the high-compression oil engines of to-day work was actually originated, invented and patented by me—namely, the fundamental factor of the whole thing—that is, the compression of pure air in the cylinder instead of an explosive mixture. I admit that Dr. Diesel carried my original idea a step further in the increased compression, but this was not until I had shown the way in the then new cycle.

After established practice it is so simple to take things as a matter of course; no one ever dreams nowadays of pulling into the cylinder a mixture of oil vapour and air on the suction stroke, and the younger generation has grown up with the knowledge that compressed pure air into oil vapour, or liquid fuel finely sprayed into compressed pure air, are the only proper cycles for liquid-fuel engines.

When I started my experiments on lamp-oil or paraffin engines in the early eighties there were only two known methods of ignition: one the constant-burning-lamp type, and the other electric ignition by battery and coil. In both cases a complete mingling of the oil vapour and air was considered absolutely essential before compression in order to obtain proper combustion. Timed ignition, of course, prevented pre-ignition. We can afford to smile at such fancies nowadays, but that was the state of knowledge when I took up my experimental work in 1884.

The goal I set myself was an engine that would work automatically without burning-lamp or electric spark, and I experimented on the cycle commingling of air and vapour on the induction stroke for four years. I may mention I made 12 engines—a vertical type (patent 14076, October 1, 1888) in two sizes, 5¼ in. cylinder, 8-in. stroke, and 7-in. cylinder, 10-in. stroke. These, as others before, met with little success—constant trouble with pre-ignition. It was not until I conceived the idea to change the cycle and compress pure air only, keeping out the oil fuel until it was wanted, that I could control automatic ignition under all compression pressures (patent 7146, May 8, 1890).

I have some of my old indicator cards taken off these engines by me as I write, and the striking similarity of these and the cards from the present-day high-compression oil engine is most marked, although, of course, my compression pressures were low.

These cards, taken 26 years ago, off these engines, show the burning up of the oil on the compression stroke, with early timed oil injection, or the slow burning of oil on the combustion or working stroke with a late-timed oil injection, or I could time the oil injection for initial pressures and temperatures. It was some few months after I built this engine that I conceived the idea of putting the oil on the *suction stroke* into the vaporiser separated from the cylinder proper by a narrow neck, and arranging the air-valve on the cylinder side of the neck to allow pure air only to be drawn up the cylinder. This also gave me automatic ignition and another master-patent cycle, No. 15994, October 8, 1890. The main idea was to give the oil more time to vaporise, as I was at this time quite convinced that thorough commingling of air and vapour on the suction-stroke was a fallacy. This engine was simple and worked well. My dream had not only come true, but I had heat and to spare. The burning lamp and electric spark were, as far as I was concerned, things of the past, and for fourteen years the automatic ignition of the Akroyd engine constituted a master-patent that was never seriously challenged.

When I had at last *two* sound working engine cycles my capital, some 16,000*l.*, with which I started out on

my work, was exhausted. I was faced with an unsympathetic world that did not want nor like oil engines. I do not pretend to be a business man; my only chance seemed to be in some firm taking up the engine on a satisfactory basis. Messrs. Hornsby and Sons, of Grantham, took up the manufacture under licence in June, 1891, and they decided to introduce the simpler of the two patent engines—viz., that with the compression of pure air on to oil vapour—which was marketed as the Hornsby-Akroyd oil engine. My health at this time was anything but good, and the former patent was allowed to lie in abeyance, as Messrs. Hornsby and Sons, who had control of both patents, found their time fully occupied with the demand that was setting up for the small-power simple engine.

The high-compression oil engine of to-day is an evolution of the Akroyd oil engines I made and sold in 1890-91, in sizes of 1, 2, 4, and 6 horse-power, at Bletchley Iron Works, Bletchley, Bucks, England, under my patent 7146, May 8, 1890, which patent embodies pure air compression, and oil timed injection with automatic ignition. These Akroyd engines worked on all lamp-oils, or paraffin or Russolene or Scotch shale-oil (gravity, 0.850; flash-point, 225 deg. Fahr.) more than a quarter of a century ago.

I decided to water-jacket a part of the vaporiser or combustion chamber in addition to air-cooling (patent 3909, February 29, 1892). This resulted in *increased compression pressures* with *oil-fuel economy*. This patent I handed to Messrs. Hornsby and Sons.

I maintain that neither the Diesel, semi-Diesel, nor 99 per cent. of the present-day high-compression oil engines are possible except with this Akroyd cycle.

It is as much for British credit as for myself that I claim the present-day high-compression oil engine is a British invention, and that the Germans should have been allowed to absorb to themselves the reputation they have in this connection is more credit to their slimness than their honesty.

When my patents expired all right and title to the use of the name "Akroyd" in connection with oil engines reverted to me, and I should naturally be only too pleased to consent to its use to designate the type of engine of which it stands as the genesis, and it is at least as palatable to our lips as Diesel. I have taken up a lot of your space, but I can only hope the subject merits it.

Yours faithfully,
HERBERT AKROYD STUART, M.I.Mech.E.
West Australia, April 28, 1916.

LESSONS FROM THE LOSS OF THE "HAMPSHIRE."

TO THE EDITOR OF ENGINEERING.

SIR,—The evidence of survivors and others relating to the loss of H.M S. Hampshire seems to now be as complete as will probably be allowed for publication. Taken in conjunction with the relative Admiralty statements, the facts are still unsatisfactory to practical seamen and marine engineers.

For example, in the opinion of the crew of the trawler "Effort," which passed the neighbourhood of the spot where the Hampshire was lost two hours after the disaster, "the sea was not so rough as to prevent small boats being launched"; but it was too rough for the escorting destroyers to "keep the sea," according to the Admiralty statement.

Trawler crews are generally more experienced in handling small boats "at sea" than any other seamen, allowing that the Navy proper have much experience in harbours, but that search and patrol vessels other than destroyers, who search "at sea," are mostly manned by ex Merchant Service seamen.

Brixham fishermen, by expert seamanship, bravery, and "hand" gear, saved many lives in the case of the Formidable under similar, or more adverse, weather conditions than prevailed in the case of the Hampshire; but in both cases (and numerous others not published) the Naval crews had not "efficient" tools for handling their lifeboats, and many other vessels, both Naval and Mercantile, are in exactly the same position; one famous liner in particular being exactly similar to the Formidable and Hampshire in that, in the event of power failure (as usual) the lifeboats cannot be manipulated by hand. It is probable, however, that nothing will be done in the matter, notwithstanding that Admiral Gough-Calthorpe (the new Sea Lord) was a signatory in 1913 to the prospective Statutory recommendation that "power should never be allowed *in complete substitution for* hand gear, but only *in addition to* it," as one of the Board of Trade Advisory Committee on Safety of Life at Sea.

Why this absolutely necessary provision is ignored in the case of power operated life-saving outfits is not clear; but that it is ignored is proved by a survivor's evidence ex the Formidable that "there being no steam available for the purpose, none of the steam pinnaces could be got afloat," while ex First Class Petty Officer Wilfred Wesson, of the Hampshire stated: "It was impossible to launch the boats properly because the derricks would not work in consequence of the water in the ship having cut off the electric current."

Relatively to the famous liner I indicate, the Board of Trade have been made aware of the facts long since. I am aware that in this case the lifeboat motors are on the boat deck instead of the power, either steam or electric, being derived from the engine room, but the outfit does not comply with Statutory recommendations nevertheless.

Yours sincerely,
R. D. ROBERTS.
5, Strathfield Gardens, New Barking, Essex,
June 18, 1916.

EASEMENT CURVES.

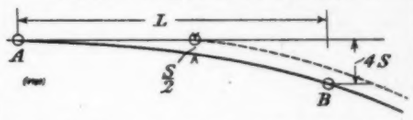
TO THE EDITOR OF ENGINEERING.

SIR,—The following table may prove useful in setting out easement curves. It seems to reduce the matter to its simplest terms. The odd seconds can be taken to the nearest 10, 20, or 30, according to the graduation of the horizontal circle.

Yours faithfully,
HERBERT CHATLEY, District Engineer,
Chinese Government Railways, Nanking-Hunan Line, District Engineer's Office, Survey District No. 1.
May 7, 1916

Transition Spiral.

Super-elevation (e) = 1 in. *per deg. of curvature.*
Length of spiral = $400\,e = L$,
Set $\frac{L}{2}$ back from tangent point of curve to A. Place theodolite over A and range in back rod on the tangent.



Plunge the theodolite and set out as follows along A B:—

Ft.				Deg.	Min.	Sec.	
25	...	...	...	0	01	52	
50	...	...	...	0	07	30	
75	...	...	...	0	16	48	
100	...	...	...	0	30	00	*End* for a 3 deg. curve.
125	...	...	...	0	46	52	
133.33	...	...	...	0	57	44	*End* for a 4 deg. curve.
150	...	...	...	1	07	32	
166.66	...	...	...	1	23	20	*End* for a 5 deg. curve.
175	...	...	...	1	31	52	
200	...	...	...	2	00	00	*End* for a 6 deg. curve.

Set up theodolite over B. Sight on to A. Plunge and turn by *twice* amount turned at A. Line of sight is now on a tangent, and the circular curve can be set out as usual.

"INDUSTRIAL DEVELOPMENT."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with pleasure two excellent letters signed "Venator" in your issues of May 26 and June 2; but, while agreeing on several points with your thoughtful and far-seeing correspondent, I would like to remind him, and others of your readers, that we shall be obliged to adopt (and, if possible, improve upon) many of Germany's methods, and that, however unpleasant the truth may be, *the only way to beat Germany in trade is to make better and cheaper articles than she makes.*

Mr. Cox's idea of keeping up wages after the war is unsound; and to raise false hopes among our workingmen will do more harm than good.

Faithfully yours,
"SESAMY."

Westminster, S.W., June 18, 1916.

REINFORCED CONCRETE REGULATIONS; STRESS ON STEEL.

TO THE EDITOR OF ENGINEERING.

SIR,—I am gratified to know that no dissentient voice has been raised with regard to my letter which you published on the above subject in your issue of May 19, in which I pointed out the unnecessary and unjust restriction of the L.C.C. relating to the stress on steel bars, in which all classes of steel bars were treated on the same basis and not allowed a higher stress than 16,000 lb. to the square inch however high the yield points.

It is significant that none of those who have been responsible for the regulation mentioned in my letter should have been able to put forward any justification for the unnecessary restriction relating to the use of steel thereby imposed.

I must therefore conclude that my letter was beyond dispute, and hope that in the near future this restriction will be removed and those firms who have been trading for some years will be allowed to continue to do so on a competitive basis.

Yours faithfully,
ARTHUR W. C. SHELF.
Caxton House, Westminster, S.W.

OUR RAILS ABROAD.—The war is still crippling foreign and colonial railway enterprise, so that our rail exports are showing a still further decline. In May they amounted to 4103 tons, as compared with 21,776 tons in May, 1915, and 56,881 tons in May, 1914. For the five months ended May 31 this year they came out at only 25,035 tons, as compared with 100,238 tons and 221,158 tons. Shipments to Argentina have practically ceased, having only amounted to 41 tons in the first five months of this year. The colonial demand to May 31 will be seen by the annexed figures to have experienced an extraordinary contraction:—

Colonial Group.	1916.	1915.	1914.
	Tons.	Tons.	Tons.
South Africa...	163	23,386	36,021
British India	15,558	21,913	75,994
Australia	876	22,302	62,491
New Zealand...	371	6,037	7,579
Canada	2	9	93

The value of the rails exported to May 31 this year was 238,532*l.*, as compared with 678,247*l.* and 1,496,481*l.*

THE ROYAL METEOROLOGICAL SOCIETY.

THE last monthly meeting of this Society for the present Session was held on Wednesday afternoon, the 21st instant, at 70, Victoria-street, Westminster, Major H. G. Lyons, D.Sc., F.R.S., President, in the chair.

Mr. J. E. Clark and Mr. H. B. Adames presented their *Report on the Phenological Observations for* 1915. The year, as a whole, approximated closely to the mean for the 25 years over which records now extend, being, if anything, a shade earlier. But this new mean for England and Wales, falling on May 18 (taking the whole British Isles the mean date is May 21), is a day earlier than that for the 20 years. Every one of the intervening years was early, whilst the four preceding these had been late. 1914 was seven days earlier than 1915, of which the outstanding features were the mild and very wet winter; the following period of drought, interrupted in most parts through July and early August, in others almost continuous through October; the genial conditions, as a whole in April and June, but with cold spells and frosts in May and June; the cold, sunless, wet July followed by a genial Autumn ending in the unprecedented November frosts. On the whole, garden and field came through fairly well, the hay and strawberry crops being the chief exceptions and a large proportion of apples malformed from the May set-back. Roses and herbaceous flowers were above the average in summer and autumn. The cold periods in spring affected migrants adversely, the mean date being April 26 compared with April 24 in 1914 and April 23 for the 20 years' mean of the *Natural History Journal* records, 1877 to 1896. An important appendix deals with a communication by Dr. Ihne, of Darmstadt, extending to the British Isles the mean date in six weekly zones of the coming of Spring in various parts, such as he has carried out for the Continent. The map representing this roughly shows that Central England corresponds to Belgium; North England and the Lowlands of Scotland to Holland, and the northern Highlands to Denmark. Ireland has similar zones, except the last, the southern parts, as also in England, coming under the two earlier zones, starting from April 17.

A paper by Messrs. Miller, Christy and W. Marriott, dealing with the *Audibility of the Gun Firing in Flanders over the South-east of England, September*, 1914—*April*, 1916," was also read. The sound of the fighting in Flanders has been repeatedly heard in many parts of the south-east of England since an early period of the war. Mr. Christy says that the sound varies considerably; sometimes, slow and deliberate firing is heard, at the rate of 3 to 12 shots a minute, each shot being quite loud and distinct. This is probably the firing of the monitors and other warships bombarding the German positions on the Belgian coast. Usually, however, the firing has been much more rapid, much less distinct, and apparently more distant. This is no doubt the sound of the fighting further inland say, around Ypres, Dixmude or Arras; it varies in rapidity from perhaps four or five shots to the minute up to more than 100. This sound *is*, as a rule, quite faint, though easily perceptible and quite unmistakable; it resembles more nearly a dull and distant thud, which is rather felt than heard. From the records collected it appears that the gunfiring has been heard at one time or another over the counties, Essex, London, Kent, Surrey and Sussex; the most distant place being about 150 miles from Ypres. Mr. Marriott has discussed the meteorological conditions under which the gunfiring was heard. The weather charts show that generally there is a somewhat irregular, or not definitely defined, distribution of barometric pressure, but mostly with a region of high pressure wedged in between areas of slightly lower pressure. These conditions are such as to produce light winds at the surface, mostly between north and east, over the neighbourhood of the North Sea. Aspect and elevation are also important factors for the hearing of the firing.

A third paper, by Lieut. E. H. Chapman, R.E., dealt with *The Relation between Atmospheric Pressure and Rainfall at a Single Station*. In this paper the author deals with the relationship between (1) actual pressure values and rainfall, and (2) mean pressure values and rainfall totals. The former relationship is small and the author deals with it by the method of probability values. Curves are given showing the chances of rain at Kew during the hour 6.30 a.m.–7.30 a.m. and during the 24 hours 7.30 a.m.–7.30 a.m., according to the height of the barometer at 7 a.m. These curves are based on data for Kew for the 10 years 1904-13. The relationship between mean pressure and rainfall totals is dealt with by the method of correlation. The coefficients obtained are high, and the corresponding regressions are shown to be very nearly linear. In this latter part of the paper, data for Kew and Valencia for the 47 years 1869–1915 are used.

EDUCATIONAL BOOKS FOR BRITISH PRISONERS OF WAR.—Arrangements have been made, with the approval of the Foreign Office, for extending to British prisoners of war interned abroad the benefits of the scheme, which has been in operation for the last year in connection with Ruhleben, for supplying selected books of an educational character to those of the interned who may be desirous of continuing their studies in any subject. An appeal is, therefore, now made for a plentiful supply of new or second-hand books of an educational character (light literature and fiction is available from other sources) to meet the needs of the many thousands of British prisoners interned in enemy or neutral countries. It is to be hoped that to this appeal there may be a liberal response. A circular explanatory of the educational book scheme can be obtained by sending a postcard addressed to the Board of Education, Whitehall, S.W., to Mr. A. T. Davies, who is in charge of the arrangements.

ON THE CO-ORDINATION OF PROPELLER RESULTS.*

By J. DENHOLM YOUNG, Wh.Sc.

(1) THE present paper was for the most part written three years ago, but was then withheld in order that certain minor points might be revised or extended. The methods about to be described have been found useful by the writer since 1908, when Mr. R. E. Froude read at this Institution† a paper on "Results of Further Model Screw-Propeller Experiments," which threw a flood of light on some of the most difficult aspects of this intricate problem. The present paper, therefore, does not describe a system complete in itself, but one by which it is intended to make more rapid and convenient the use of the constants, efficiency values, blade-width values, and other data already established by Mr. Froude, Mr. D. W. Taylor, and others, and to compare actual results of large propellers with these values, with a view to obtaining guidance in the solution of propeller problems under varying conditions. The writer is indebted to Mr. R. E. Froude for his consent to utilise his published data in the present paper.

(2)‡ In 1892 and 1895 the writer described before the North-East Coast Institution of Engineers and Shipbuilders a graphic method of applying the law of comparison both to ships and to propellers, and, although in the light of the experience of the last 15 years, much of the writer's paper of 1895 requires correction, experience appears to have confirmed the main principle outlined, namely, the applicability of the law of comparison to the behaviour of propellers in general throughout a wide range of speed. This principle was that, when the revolutions of similar propellers of different diameters working with the identical real slip ratio are inversely as the square roots of the diameters, the thrusts of these propellers are as the cubes of the diameters, and the horse-powers are as the $\frac{7}{2}$ powers of the diameters. A limit to this range of applicability is the point at which cavitation begins, dwelt upon by Mr. Sydney Barnaby in the discussion upon the 1895 paper referred to, and since elaborated by Mr. Barnaby and others in several well-known papers. It is scarcely necessary to mention that, beyond the point where the law of comparison breaks down through cavitation, any of the usual constants employed in calculation up to that point require modification.

(3) The method of calculation for propellers described in 1895 consisted in plotting the curves on tracing-paper laid over a logarithmic field, ruled in such a manner that indicated horse-power for different dimensions at corresponding speeds was read off automatically without the intermediate use of constants. A difficulty in usefully applying the results thus plotted was that, with the speed as plotted, wake value existed, and when using the scale for a different size of propeller, the same wake value seldom held good, thus rendering direct comparison very limited in its application. It has, therefore, been found advisable to alter this diagram, and plot the indicated horse-power on revolutions instead of on knots.

CONSTRUCTION OF THE LOGARITHMIC FIELD.

(4) A logarithmic scale of indicated horse-power is laid off horizontally, and of revolutions vertically, both of size and range suitable for the purpose in view. Along the lower portion of this area is arranged a third logarithmic scale representing diameter, in which the spaces measured horizontally have 3.5 times the magnitude of the corresponding spaces on the indicated horse-power scale. This diameter scale is not horizontal, but slopes downward to such a degree that revolutions corresponding to different diameters are automatically varied in inverse proportion to the square roots of the diameters; *i.e.*, the vertical difference between the heights of the 4-ft. diameter mark and the 16-ft. diameter mark is the same as the difference of space between the 400 revolutions mark and the 200 revolutions mark, on the vertical scale (see Fig. 2). On the diagram the finer subdivisions used in actual work are omitted.

If thrust is to be dealt with instead of horse-power, the relation between the spaces on the thrust scale to the spaces on the diameter scale must be in the proportion of 1 : 3 instead of 1 : 3.5, and the scale can be arranged to indicate tons or lb. instead of horse-power. Having constructed this field diagram, a piece of tracing-paper is laid over it, and a line drawn coinciding with the sloping edge of the diameter scale. A mark on this line serves as a gauge point, which can be moved up and down the scale to any diameter. (See paragraph 6 for surface ratio.) For purposes of analysis, one sheet may be confined to the registration of the results of propellers of one particular pitch ratio.

(5) To record the results of any propeller, the gauge point on the tracing-paper is placed upon the diameter of the propeller, and the propeller horse-power (P.H.-P.) laid off upon revolutions. A straight line drawn through any spot representing horse-power at a certain slip value and parallel to the line of cubes on the basis diagram will give the horse-power at this slip per cent. for any revolutions of this propeller, upon the assumption that the horse-power varies as the cube of the revolutions for constant slip per cent., and the gauge point can be moved up and down the diameter scale to find the corresponding horse-power and revolutions of any similar propeller of different diameter.

VARIATION IN SURFACE RATIO.

(6) It will evidently greatly facilitate calculation and analysis if we can automatically estimate the results of one surface ratio from the results of a propeller of different surface ratio. Mr. R. E. Froude's B values given in his 1908 paper enable this to be done very conveniently. A reversed logarithmic scale of suitable range and magnitude is extended from the gauge point on the tracing-paper already mentioned, and points on this scale corresponding to B values for different surface ratios and number of blades are used in conformity with each model, instead of a single gauge point. The results of all propellers of standard shapes are thus reduced automatically to those of propellers having the same diameter, the same surface ratio, and the same number of blades.

(7) By comparing the performances of many similar propellers under different conditions, reduced to a uniform diameter, much useful information can evidently be gathered together, and the logarithmic method of analysis seems specially adapted, not only for tracing indices of curves, but also for exhibiting variations of wake values; *e.g.*, by placing together the power curves of two similar propellers attached to dissimilar ships—one ship, say, a torpedo-boat with little scope for variation in wake value, the other a vessel of much larger dimensions and coefficient—the variations in wake values of the larger vessel are brought more into prominence.

(8) Differences in the relative positions of "spots" on the curves of two similar propellers working in known wakes can also be investigated; *e.g.*, differences due to immersion or to thickness or to material. In the writer's experience the differences in horse-power or revolutions due to variation in pitch ratio and slip ratio over a wide range of speeds appear for full-sized blades to be in very accurate agreement with Mr. R. E. Froude's 1908 constants, and with the heavier blades used in mercantile marine practice appear also to be relatively proportioned to these constants.

(9) In order to facilitate the utilisation of Mr. Froude's constants, the "propeller horse-powers" calculated from these constants at various slip ratios and a useful range of pitch ratios for a 9-ft. diameter 4-bladed propeller of 0.4 surface ratio advancing at a speed of 10 knots, have been plotted logarithmically on revolutions in the diagram Fig. 2, and arrange themselves in the form of a distorted parallelogram subdivided into smaller parallelograms. This subdivided figure retains its shape and size on any part of the logarithmic field, so long as indicated horse-power varies as R^3, thus saving re-calculation for different diameters, while parallel straight lines representing values proportionate to R^3 will give the indicated horse-power corresponding to any revolutions other than those for which the calculation is originally made (Fig. 2).

If, then, it is desired to find either—

(1) The requisite diameter at given revolutions and pitch ratio, indicated horse-power, and slip per cent.; or
(2) The requisite revolutions at given slip per cent., indicated horse-power. and diameter and pitch ratio; or
(3) The requisite pitch ratio with given diameter and indicated horse-power and slip per cent.; or
(4) The suitable indicated horse-power with given diameter, pitch ratio, slip per cent., and revolutions; or
(5) The limits of surface ratios between which any of the above conditions are feasible,

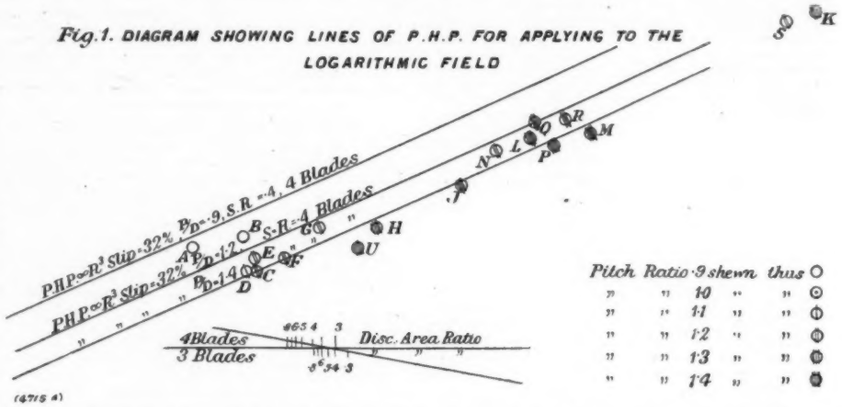
then this diagram aids the rapid solution of any variations of the above problems without further calculations, by simply working the tracing-paper up and down the scale. It is evident that if one of the four conditions, such as diameter or revolutions, is not fixed, there will be a considerable range of practical solutions to any one problem.

(10) A selection of "spots" from actual full-sized propellers is also given on the diagrams, varying in size and power from a trawler propeller 7 ft. 9 in. diameter, 196 indicated horse-power, to that of the City of Rome, 23 ft. 6 in. diameter and 12,000 indicated horse-power. The particulars of ships and propellers are given on Table I., the distinguishing letter in the first column corresponding to that given on the "spots." The pitch ratios are distinctly marked, and it will be noticed that all the spots come within the broad limits of Mr. Froude's experimental results, and their relative positions as regards pitch ratio correspond generally with these results. It appears, however, that the spots of cargo-boat propellers at slow speeds give a higher horse-power than one would expect at maximum efficiency, even after making due allowance for all the circumstances. This is referred to later on. With a few records of actual data from the propellers of existing vessels, it is safe to estimate results for propellers differing in pitch and surface by graphic measurement from corresponding spots on the parallelograms referred to, allowing for any probable difference in wake, &c. Thus, although different designers use various different constants for arriving at propeller diameter, pitch and surface for cargo boats, channel boats, liners, &c., one set of Mr. Froude's results plotted down in this way enables the designer to make an indefinite number of direct estimates without troubling about constants at all.

(11) One of the most useful purposes to which the graphic use of Mr. R. E. Froude's constants can be put is to estimate the alterations required when a particular propeller is found unsuitable for a particular vessel. Two cases which have come under the writer's observation may be quoted, the first in which the original propeller was too small, the second in which the original propeller was too large.

The first was a tank steamer about 295 ft. long, having engines with cylinders 21 in., 35 in., 57 in. by 36 in., and a propeller 13 ft. 6 in. in diameter, 14 ft. pitch, and with a surface of 62 sq. ft. A five years' average gave 8.33 knots and 76.15 revolutions. The engines had been designed to run at 80 revolutions, but steam could not be kept to maintain this, and the slip, about 20 per cent. plus the wake, was too much for a cargo vessel. A new propeller was designed, having a diameter of 13 ft. 9 in.

Fig. 1. DIAGRAM SHOWING LINES OF P.H.P. FOR APPLYING TO THE LOGARITHMIC FIELD



(4715 4)

(11) The second case was one of a very full vessel, in which the propeller, with some show of reason, had been made with too much diameter, too little pitch, and too much surface and thickness of blade, the heavy propeller evidently absorbing a larger proportion of horse-power than was advantageous in simply being driven itself. The alterations indicated by the diagram as advisable were carried out, with the result of a substantial gain in speed.

(12) It is not necessary here to do more than refer to the effects due to difference in thickness of blades, which can be laid off from known data, such as the results published by Mr. D. W. Taylor. As mentioned in the writer's 1895 paper, the thickness of propellers designed under the law of comparison will not be similar, and may have to be allowed for.

(13) It may here be pointed out that should the horse-power of a particular propeller at uniform slip ratio not vary exactly as the cube of the speed, an estimate founded on the law of comparison would possibly form a safer basis of calculation than a constant derived strictly from V^3. This was a point which the writer had in mind when writing his 1895 paper, and although, generally speaking, the proportion of power to revolutions does not appear to vary sensibly from the cube throughout a considerable range, yet it appears to be not impossible that variations may be found of sufficient importance to be taken into account. Mr. D. W. Taylor has stated that in his experiments with very narrow blades the thrust varied as a greater power than the square of the speed, and with very broad blades the thrust varied as a lesser power than the square. Any such difference in the index could, if constant, and accurately ascertained for water, be allowed for in this diagram by having a separate sloping base line passing through each B value on the tracing-paper.

(14) Referring again to the spots shown on the diagram on Fig. 1, an allowance of 82 per cent. was made for propeller horse-power in the case of cargo-boat engines, where the pumps were worked off the main engines, and 90 per cent. in the case of the quicker running naval machinery. The writer considers 18 per cent. rather an excessive allowance for friction, especially when any good metallic packing is used in the piston-rod glands; but notwithstanding this large allowance, the indicated horse-

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* Paper read before the Institution of Naval Architects, April 12, 1916.

† Trans. I.N.A. for 1908, vol. l., page 185; see ENGINEERING, vol. lxxxv., pages 539, 546, 602.

‡ Trans. of North-East Coast Institution, 1892, vol. ix., and 1895, vol. xii.

power of the cargo-boat propellers is in excess of what would be given by 32 per cent. real slip. Whether this excess is entirely due to the difference between face pitch and virtual pitch, or partly to the difference in the index of R, referred to by Mr. Taylor, has, the writer submits, which we see strongly developed when a vessel is moored and using her engines, and less strongly when a heavy vessel is slowly getting under way, may also exist in a proportionately larger degree at low steady speeds than at high speeds (especially with broad blades), causing a deficiency which is happily becoming less marked as more data are accumulated. A wake diagram given by the writer in his 1895 paper was a rough attempt towards a general solution of this question at normal speeds of ships; but the diagram now appears to require con-

Fig. 2. DIAGRAM OF LOGARITHMIC FIELD, SHOWING PROPELLER RESULTS BROUGHT TO TWO DIFFERENT DIAMETERS.

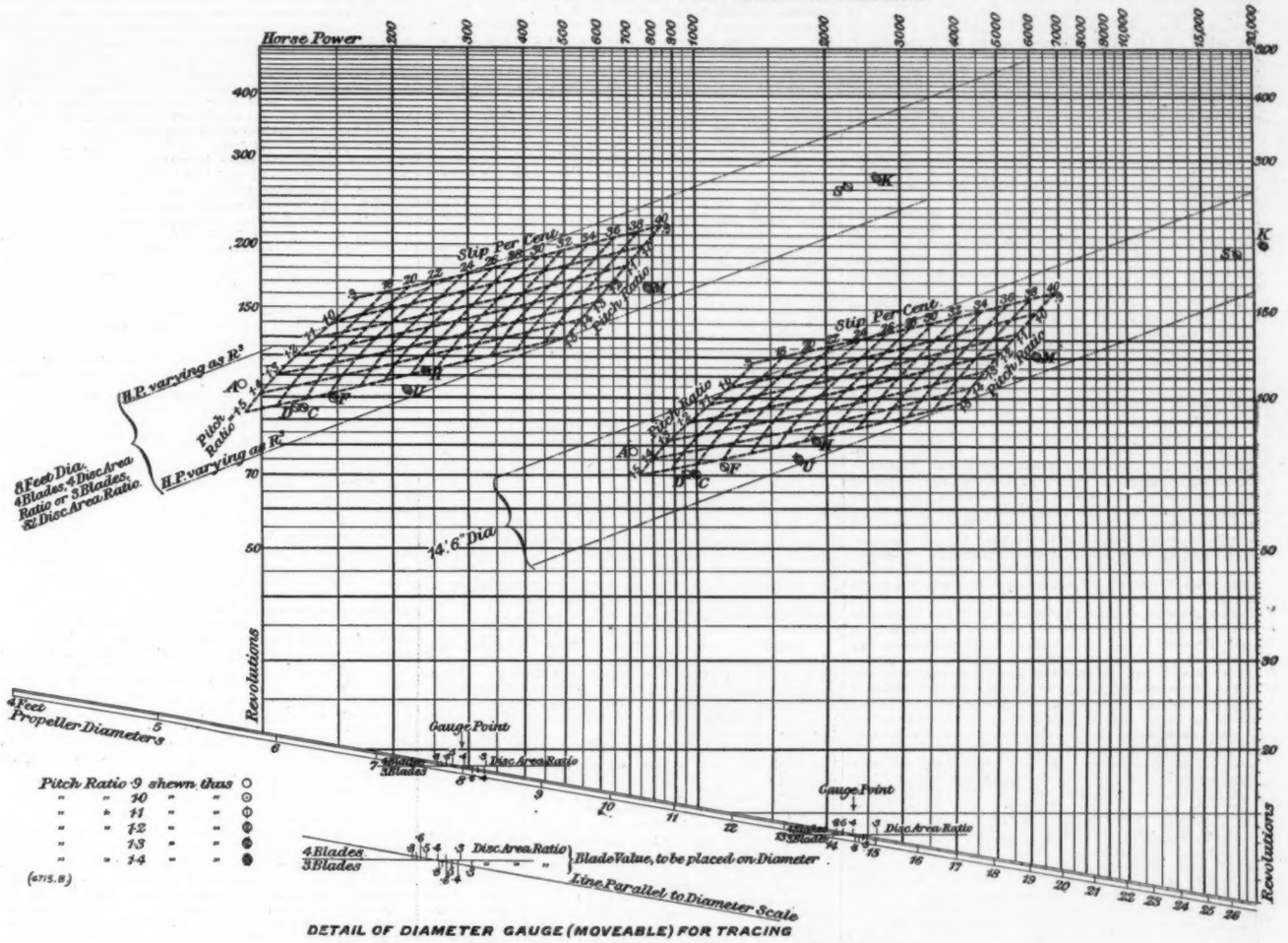
Horse Power
Revolutions
Slip Per Cent.
Pitch Ratio
H.P. varying as R³
8 Feet Dia. 4 Blades. 4 Disc Area Ratio or 3 Blades. .52 Disc Area Ratio.
14'6" Dia
4 Feet Propeller Diameters
Gauge Point
Disc Area Ratio
4 Blades
3 Blades
Blade Value, to be placed on Diameter
Line Parallel to Diameter Scale
Pitch Ratio .9 shewn thus
DETAIL OF DIAMETER GAUGE (MOVEABLE) FOR TRACING

TABLE I.—PARTICULARS OF SHIPS AND PROPELLERS.

—	Length W.L.	Breadth.	Draught.	Block Co-efficient.	Speed.	I.H.P.	Pro-peller H.P.	Revs. per Min.	Ap-parent Slip.	Propeller Dia-meter.	Pitch (Face).	Surface (ex-panded).	Disc-Area Ratio.	Pitch Ratio.	No. of Pro-pellers.	No. of Blades.	Remarks.
	ft. in.	ft. in.	ft. in.		Knots.				Per cent.	ft. in.	ft. in.	sq. ft.					
A.	380 0	52 9	23 6	0.8	10.47	1,628	1,335	70	1.13	17 6	15 0	85	0.354	0.86	1	4	Tank steamer. Cast-iron propeller.
B.	372 0	50 9	24 10	0.776	11¼	2,350	1,927	73	5.5	17 9	16 6	100	0.4	0.9	1	4	" " " "
C.	250 0	35 0	17 6	0.77	10	1,114	914	69	13.4	14 6	17 0	62	0.315	1.17	1	4	Cargo " " "
D.	235 0	34 0	16 0	0 .72	8.5	740	607	73	15.7	13 0	14 0	46	0.32	1.07	1	4	" " " "
E.	294 0	38 0	23 0	0.75	9.6	1,095	898	75	16.5	13 9	15 9	75	0.5	1.15	1	4	Tank " " " (sea performance).
F.	150 0	25 0	12 4	0.72	9	380	311	89½	9.25	9 9	11 4	33	0.44	1.16	1	4	Cargo steamer. Cast-iron propeller.
G.	97 6	20 5	8 2	0.34	9.1	196	161	115	10.8	7 9	9 0	19½	0.4	1.16	1	4	Steam trawler. Cast-iron propeller.
H.	560 0	52 3	26 0	0.62	16.5	12,000	9,840	62	18½	23 6	33 0	164	0.377	1.4	1	4	s.s. City of Rome.
J.	211 0	28 2	10 0	0.65	12.2	1,300	1,100	113	17	10 7	13 6	46	0.52	1.27	1	4	Channel cattle steamer. Cast-iron propeller.
K.	130 0	13 9	4 0	0.45	19.5	969	872	316	21	6 0	8 3	11.6	0.41	1.375	1	3	Torpedo-boat. Steel propeller.
L.	315 0	48 7	19 2	0.51	19.7	8,053 / 2	3,893	119½	18.2	14 6	20 4½	57	0.345	1.4	2	3	U.S.N. Philadelphia.
M.	300 0	49 2	18 9	0.51	19.5	9,717 / 2	4,370	125	15½	13 6	18 9	57½	0.4	1.38	2	3	U.S.N. San Francisco.
N.	300 0	46 2	17 10	0.51	18.2	6,452 / 2	2,903	114½	8 (?)	14 0	17 6	54½	0.355	1.25	2	3	U.S.N. Charlestown (slip uncertain).
P.	315 0	48 6	19 10	0.51	20	9,877 / 2	4,444	116½	18½	14 6	20 0	57	0.345	1.37	2	3	U.S.N. Baltimore.
Q.	311 0	49 2	11 3	0.51	19	8,674 / 2	3,904	127	20	14 6	19 0	52.8	0.38	1.3	2	3	U.S.N. Newark.
R.	228 0	36 0	14 2	0.5	15.8	3,341 / 2	1,503	152	20½	10 6	13 2½	26.5	0.3	1.25	2	3	U.S.N. Concord.
S.	246 0	26 5	9 6	0.4	21.2	3,916 / 2	1,762	269	14.8	7 9	9 4½	16	0.34	1.2	2	3	U.S.N. Vesuvius.
U.	210 0	27 0	13 0	0.62	12	998 / 2	813	82	14	12 0	17 3	36	0.32	1.44	1	4	Cargo and passenger steamer. Cast-iron propeller.

still to be definitely determined. Narrow three-bladed propellers at low slip ratios appear to give at low speeds results in the opposite direction, also confirming Mr. Taylor's experience, but there are few examples of narrow three-bladed propellers designed nowadays.

Another point appears to be worthy of consideration, namely, that what Mr. Taylor calls "propeller suction," greater volume of water to be put into circulation per revolution in advance of the propeller at the lower speeds, even when the slip per cent. as measured on distance travelled is the same.

(15) Many apparent deviations from the law of comparison, when results are plotted down, are probably due to our, as yet, incomplete knowledge of wake values, a siderable modification; no account was then taken of the variation of wake with speed or position of screws, struts, or bossing, or other factors, upon which subject Mr. W. J. Luke has recently given such valuable information.*

* Trans. I.N.A., vol. lii., page 43; see ENGINEERING, vol. lxxxix., pages 374, 392.

(16) Reference has been made in paragraph 2 to the question of cavitation, and to the limit which it sets to the application of the law of comparison. If, for example, cavitation for a particular model of propeller be assumed to depend upon tip speed, the effect on this diagram would be to block off a triangular portion from the right-hand top corner of the logarithmic field on Fig. 2. The spot for the propeller marked K (3 blades 0.4 surface ratio) would be just about this limit at 8 ft. 6 in. diameter where shown, and considerably beyind the limit at 14 ft. 6 in. diameter where shown, necessitating a different propeller. Much evidently remains to be investigated, and now that mechanical gearing has brought the slow-running propeller into vogue again, even in turbine steamers, it would appear worth while to pursue still further the investigation of the general phenomena surrounding propeller action, at moderate as well as at higher speeds.

Colonel G. Rota, R.I.N., has sent to the Secretary of the Institution of Naval Architects the following written contribution on the paper :—

Mr. Denholm Young's paper will be well received by all those interested in screw propeller design. The author's idea of representing the "constants" obtained by screw propeller model experiments, in a practical form, requiring no numerical calculations in the design work, is a very valuable one.

In 1893 Mr. Young was the first to introduce the use of hull resistance (or its functions) and speed curves plotted on logarithmic co-ordinates on a transparent sheet which moved in a given manner on the logarithmic field, and made it possible to obtain in an easy and direct manner, and without calculation, the hull resistance values corresponding to several ship sizes. In an analogous way he traces a logarithmic field of I.H.P. or P.H.P. and revolutions, slip, pitch ratio, which may be referred to screws of any diameter, but similar in shape to a standard one, introducing also correction-coefficients for the number of blades and disc area ratio. In other words, a graphic method of representing the "constants" of a standard screw working on a large range of pitch ratio and slip values. Having taken a great interest in Mr. Young's method, I had introduced it in Italy, and I succeeded in working out its extension to the graphic calculation of the skin resistance correction, so as to obtain by the graphic method the two parts of the total hull resistance, namely, wave resistance and skin resistance. This method is detailed in the *Rivista Marittima*, May, 1893, and in "La Vasca per le esperienze d' Architettura Navale," 1900, and is generally used in the Italian Navy in all ship resistance calculations.

Last year I had an opportunity of co-ordinating the results of several model screw experiments for different shapes of blades, pitch ratio, and disc area for different classes of ships, and I arranged to plot them on log-arithmic-scale diagrams in a similar manner to that used for hull resistance calculation. It was not merely one standard screw adapted to several pitch ratios and disc area ratios, but of several screws differing both in blade pattern and slip ratio, the latter to be applied just as they were tried. I thus obtained a first set of results which became the starting point of a series of further researches, which are now being carried out at the experimental tank in Spezia. The results of each screw plotted on the base of thrust and speed at different slip ratios give the data necessary for any further calculation relating to the application to full-sized vessels. I would have had the honour of submitting this work to the Institution of Naval Architects for the Spring Meetings if the special circumstances under which we now hold our meetings had not prevented me from completing it in proper time. It is now being printed in Italian. The subject is analogous to that of Mr. Denholm Young's paper. It is evident that, for actual application, the value of the thrust-deduction factor $\left(\frac{R}{S}\right)$ and wake factor $\left(\frac{V}{V_1}\right)$ must be known beforehand, since the diagrams must take account of the values of S and V_1.

I have lately been in a position to compare the results obtained with full-sized propellers with those of models, and I have had a further proof of the reliability and rapidity of the graphic method just referred to in the ordinary screw propeller problems.

The agreement of my work with Mr. Young's must be considered as evidence of the need that exists for all who are interested in practical matters to have easy and rapid methods, dispensing with tiresome and cumber-some calculations; we must all acknowledge that the whole merit of the advantage obtained with this method is due to Mr. Denholm Young, who first introduced it, thus laying the foundation for all further developments.

THE DEVELOPMENT OF ELECTRIC POWER PRODUCTION AT CHICAGO.—In an article recently published in the *Electrical World* Mr. L. A. Ferguson describes the development of power-station practice at Chicago. In the early days there were more than 25 separate generating stations, the fuel consumption per kilowatt here being 10 to 15 lb. of coal in the smaller and perhaps 6 lb. in the larger and better-equipped stations. The Fisk station was opened in 1903 with three 5000-kw. units, the coal consumption of which was 115 per cent. more than that of the modern units recently installed. The cost per unit was also greater by the same amount, whilst the cost of attendance was 170 per cent. more. Moreover, in the 13 years which have elapsed since the station was opened the cubic capacity occupied per rated kilowatt has diminished from 146.5 cub. ft. per kw. to 31.3 cub. ft.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, June 7.

NOTWITHSTANDING the very largely oversold condition of the steel industry, buying is active, especially on European account; Russia especially is an active buyer and has just placed an order for 70 narrow-gauge engines, and it is understood she is in the market, or soon will be, for 800 larger locomotives as an addition to 400 smaller engines placed some time ago. The French Government has ordered 25 engines from Baldwin, and the New York Central is now in the market for 100 engines. French interest has closed for 35,000 tons of rails for delivery before next May. Italy is in the market for 15,000 tons of blooms for Italian rail mills to be shipped during the last quarter. The Japanese ship-builders have ordered 30,000 tons of plates and their agents here are awaiting cable instruction for final signature. The Russian Government is in the market for 150,000 tons of barbed wire, but is finding difficulty in placing it, especially for that portion which is wanted for delivery this year. The usual activity prevails at all steel centres for structural material and plates. Lower ocean freight rates are serving to stimulate steel exports. To-day's inquiry includes some 40,000 tons of Bessemer pig-iron, also large lots of tin-plate, barbed and plain wire, rivets, wire rods and munition material in general. A Cleveland concern sold 12,000 tons of Bessemer pig-iron for export to Italy, freights having been reduced from 42 dols. to 30 dols., with prospects of 25 dols. prevailing in a short time. Large consumers of electrical equipment in France, Italy and Japan are conspicuous buyers in the American markets. A European inquiry is in the market to-day for 4,000 cars. Inquiries for locomotives now pending will call for 30,000 tons of plates. The French Government have placed orders with the Pennsylvania Steel Company for 35,000 tons rails, and domestic roads have ordered 150,000 kegs of spikes and bolts. Both coal and coke have advanced in price owing to a large restriction in output due to strikes. A large volume of steel business is awaiting the opportunity for mill acceptance.

REFERENCES TO TECHNICAL BOOKS.—The Coventry City Libraries publish slips giving references to technical articles in Proceedings of Societies and in technical journals which are likely to interest readers, and which can otherwise only be found by considerable labour in searching. The latest is dated June 1, and deals with Aluminium and its Alloys.

"THE MAN POWER OF THE NATION."—Acting on a widely expressed wish, we have collected and have issued in book form a number of articles, published in ENGINEERING, having a direct bearing on industrial efficiency, not only in connection with war munitions, but with the work of rehabilitating trade after the war, and of extending our commercial operations. As is stated in the prefactory note, "there is need for broader views alike by employers and workers on all phases of industrial economics, not only during the present world's crisis, but also in view of the certainty of more stringent competition in the immediate future. The cheapening of production can proceed side by side with higher earnings by the workers; but there are conditions which must be observed by all concerned, and it is the purpose of the articles to state those conditions." A list of the articles affords some idea of the scope and general treatment of the subject: Man Power of the Nation; the Duty of Economising; the Self-Sacrificing Patriotism of Employers and Workers; Industrial Economics, Present and Potential; a First Essential to Industrial Expansion; the Increasing Importance of Automatic Machinery; Workers' Encouragement of Industrial Expansion; Shorter Hours and "Selling Prices;" Fatigue in Factory Work; the Prevention of Accidents; the Foreman of the Future; the Pitfalls of the Promoted; New Markets for the Future; Imperial Commercial Unity; and the Relation of School and Factory. The book is published from the offices of ENGINEERING, and the price is 1*s.* net, or, including postage, 1*s.* 1½*d.*

IMPORTANT WAR WORK FOR ENGINEERS UNDER THE WAR OFFICE.—250 examiners of engineer's work are urgently required for service at home. The qualifications essential are as follow :—(1) An apprenticeship (or its equivalent) of not less than three years in engineering workshops, followed by further experience in shops producing engineering work of an *accurate* nature. Some portion at least of the experience must be recent, as the rapid advances of late years in workshop practice have rendered earlier experience quite out of date as regards this work. (2) Familiarity with, and skill in using, fine measurement tools (micrometer, vernier caliper, vernier protractor, height and depth gauges, &c.). (3) Experience in actual detailed inspection of engineering parts, and knowledge of the working methods needed for setting up for examination and measurement, pieces of an awkward shape or complicated character. (4) A complete knowledge and comprehension of the meaning and object of limit systems; a working acquaintance with one or more such systems (preferably including the "Newall") and good experience in the use of limit gauges. (5) A reasonable standard of education, and ability to render clearly written reports. Rates of pay :—50*s.* to 60*s.* weekly, plus allowance of 21*s.* weekly up to three months at one station, also a special war increase of 4*s.* per week, and overtime at common time rates after 48 hours per week. Preference will be given to men over military age, men in the older married groups and men unfit for General Service; but men of any age may be taken if they are highly skilled. All applications should be addressed: "Room 268, A. G. 2 B, War Office," enclosing credentials.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—There has been no resumption of business in the Glasgow pig-iron warrant market; and now only 1,000 tons of No. 3 Scotch iron are in stock in the store.

Scotch Steel Trade.—It is scarcely possible, with the resources now at their command, that local steelmakers could further increase their already enormous output, and nothing but the most rigid supervision could maintain it at its present extraordinary level. As it is, no falling-off can be permitted during the next two months, for the high pressure must continue unceasingly if the war contracts for steel, &c., are to be satisfactorily carried through. In its own way the postponement of the Glasgow Fair Holidays till the latter end of August should have the desired effect of accumulating something like the required sufficiency of war material. Although ordinary mercantile work is rather seriously curtailed in consequence of the whirl of activity on Government account, some new business is passing in the home market, and while the export trade is as satisfactory as could be expected under the circumstances, many factors militate against any further development meantime. Orders could not be more plentiful, every steelmaker being abundantly booked up. The scarcity of hematite is an occasional barrier, although the licensing restriction on exports has undoubtedly placed a better supply on the home market. While prices keep firm, and those for home trade are fixed, for export ship-plates are quoted at 13*l.* 15*s.* per ton and up to about 14*l.*; boiler plates may be 15*l.* 5*s.* to 15*l.* 10*s.*; and angles 14*l.* and up.

Malleable-Iron Trade.—There is no cessation of the overwhelming activity in the malleable-iron trade, the smaller sizes of bars particularly being much in request on Government account. In consequence very little is available for ordinary purposes or for stock by the time that the demands of our own and the Allied Governments have been satisfied. Prices are on the increase and "Crown" bars are now quoted 14*l.* 2*s.* 6*d.* per ton net f.o.b. and upwards.

Scotch Pig-Iron Trade.—While the demand for Scotch pig-iron continues to be well-nigh abnormal, so strong has been the demand for hematite that steps are being taken further to increase its production. With this end in view there is just a possibility that were the necessary labour available opportunity would be taken to re-light various furnaces which have been out of blast for some considerable time on account of the scarcity of skilled workmen. The licensing restrictions and the large local consumption of ordinary iron for Government requirements continue to have a detrimental effect upon the mercantile export trade, very little oversea business being put through. Prices of makers (No. 1) iron are unchanged at Clyde, Calder, Summerlee and Langloan, 130*s.* per ton; Gartsherrie, 131*s.* 6*d.* (all shipped at Glasgow); Eglinton, 126*s.* 6*d.*, and Glengarnock, 130*s.* (both at Ardrossan); Dalmellington, 126*s.* 6*d.* (at Ayr); Shotts and Carron, 130*s.* (both at Le it

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NAVAL ENGINEERS HONOURED.—*The London Gazette* of Thursday, June 22, announces the following honours to naval engineers :—Companions of the Distinguished Service Order :—Engineer Commander Henry Frank Smith, R.N., in recognition of his services in one of the cruisers engaged in the North Atlantic Patrol since the outbreak of war; Engineer Lieutenant-Commander Charles Alfred Norton Williams, R.N.R., in recognition of his services in charge of the engine-room of H.M.S. Alcantara on February 29, 1916, during the action with S.M.S. Greif. Distinguished Service Cross :—Engineer Sub-Lieutenant James William Grant, R.N.R.

WATER-PRESSURE REGULATING APPARATUS.—In our issue of April 28 we gave an illustrated description of a water-pressure regulating apparatus constructed by the British Electric Plant Company, Limited, of 76, Vincent-street, Glasgow, for the Falkirk and Larbert Water Trust. The makers ask us to add a supplementary note about a very simple and effective device designed by Mr. Charles Massie, engineer to the Trust, which was fitted after the plant had been set to work. This device can be seen in Fig. 6, page 404 *ante*, immediately above the starter, and consists of a weight which on release trips the main switch, the weight being released through the medium of a simple cam arrangement actuated by a small hydraulic piston operating in a cylinder connected to the water main. The function of the device is automatically to shut down the pumping set during periods of light load (such as night) enabling the district to be supplied by gravitation.

A NIGERIAN COALFIELD.—The discovery of coal at Udi in Southern Nigeria marks a new and most important epoch in the history of West Africa. The discovery was made in the course of the Mineral Survey of Southern Nigeria, which was associated with the Imperial Institute. Following on the very favourable report of the Imperial Institute, steps were taken by the Government to work the field, which is no longer in the experimental stage. Ten thousand tons of the coal have, in fact, already been mined and stacked ready for use. The coalfield is in immediate proximity to the new Nigerian Eastern Railway from Port Harcourt, whence the distance is only 150 miles, and when this line is opened for traffic —some time this year—transport can begin at once, and the coal be at the service of the whole of Nigeria. Many specimens of Udi coal have been very fully examined, and the fuel value definitely determined at the Imperial Institute.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The irregular manner in which the supplies of all classes of fuel have been coming to hand during the last few days reveals the fact that the colliers did not work during the Whitsuntide period so zealously as they were credited with doing. In certain cases the pits have only even now got back to the normal working. The lack of the maximum output has tightened the market all round, and particularly for manufacturing fuels. The present system of the Ministry of Munitions to make the respective collieries responsible for the fuelling of particular works has answered well, and this alone has prevented any serious delay arising. The prior claims of the works, however, has created a shortage in other channels, which have had to be sacrificed for the munition establishments. The general position, therefore, is once more dislocated, and arrears are creeping up. The local demand for steam coal, cobbles and nuts, is on a large scale. Fuel for gas companies can only be secured upon contract account, as the open market contains no spot lots. House coal continues to meet with a brisker inquiry, but the meagre supplies do not permit orders to be expeditiously met. Slacks are scarcer and dearer. Shipments are active, especially for the Russian and French ports. The Russian business is the more urgent, for the end of the open season for shipping to the Russian ports fast approaches. Neutrals still offer tempting prices for South Yorkshire fuel, 40*s.* per ton at pits being a common figure. The home and Allied requirements do not leave much of a surplus for the neutral customers. Quotations:—Best branch hand-picked, 20*s.* 6*d*; to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; small, 8*s.* to 9*s.*

Iron and Steel.—The most pronounced features are the shortage of labour and the continued scarcity of materials. A scheme is afoot, with the sanction of the military authorities, to reserve for the works a large proportion of the married men over 35 years of age, and also younger men who have not been certified for general service with the army. Other auxiliary help will be enlisted, and there are many small shopkeepers acting as part-time munition workers. Materials are by no means increasing in supply at the same ratio as does the local demand. The recent opening of the new national factories has not improved the position. British billets are a comparatively short supply, and the American commodities are too high in price to make their use general. The latest markings are as under:—Bessemer acid, 14*l.* to 15*l.*; Siemens acid, 15*l.* 10*s.* to 16*l.*; basic hard, 11*l.*; ditto soft, 11*l.*; hoops, 17*l.* 2*s.* 6*d.* to 18*l.* There is a particularly serious scarcity in hematites, and the position gives rise to much anxiety. Production is not keeping pace with the demands and drastic efforts are now being made to increase the supply and accelerate the output. Furnaces are being converted from foundry to hematite and additional furnaces are being put down. More labour will be required if full benefit of these alterations and extensions is to be secured. Forge and foundry irons are being demanded on a greater scale than during May. Lincolnshire brands are both quoted at 91*s.*, whilst 87*s.* 6*d.* is being paid for Derbyshire forge and 89*s.* 6*d.* for foundry. Finished-iron works are not as busy as usual, although there is a good demand for bars, South Yorkshire "Crown" brands being marked at 13*l.* 15*s.* to 14*l.* India has been furnishing this country with supplies of steel, while the Allied Powers have purchased heavy quantities of shell bars, forgings, and barbed wire from the United States. The end of the month concludes the period for which the official iron and steel prices operate. It is anticipated that the quotations will be raised all round on the representations of the makers, but not to the extent of 5*s.*, which they declare is justified. Local contracts entered into for deliveries of common iron at 87*s.* 6*d.* are subject to any subsequent revision of the prices tariff. Wire-drawers are very busy. There is a constantly growing demand for files, Russia being a very heavy buyer. The Government are inviting tenders for 60,000 hollow-ground razors.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Production of Pig-Iron.—The promised increase in the output of pig-iron by the re-starting of idle blast-furnaces has not yet been fulfilled, but preparation to that end is well advanced, and with the removal of the chief obstacles more furnaces are likely to be blowing at an early date. It is understood that more coke is now forthcoming, and as the other difficulties to putting idle plant into operation have been overcome, pig-iron producers consider that they are now justified in re-lighting furnaces that have not worked for some time past. The number of furnaces at present in blast in this district is 69, of which 28 are running on Cleveland pig, 30 are making hematite, and 11 are manufacturing special kinds of iron.

Cleveland Iron.—The demand for Cleveland pig is very insistent, and a larger output would be readily taken up. The Control Committee continue to distribute supplies to home consumers very satisfactorily under the existing conditions. For home use the prompt price of No. 3 Cleveland pig is 82*s.* 6*d.*, but it is quite a nominal figure, as none is purchasable for this month's delivery, and with the incoming of July the maximum quotation becomes 87*s.* 6*d.* A fair number of July-August contracts are understood to have been arranged at the latter figure, and buyers are quite prepared to pay the price for delivery to the end of September, but makers as a rule hesitate to commit themselves quite so far ahead. Confirmation is not forthcoming of a rumour to the effect that it is proposed to fix a maximum price for export iron. Sellers, however, are keen to dispose of pig for shipment abroad. They offer No. 3 Cleveland rather freely at 100*s.* and probably would not hesitate to accept a rather lower figure. Licences for export are still difficult to obtain and are not procurable at all except to our Allies, but the opinion is expressed that permits for delivery to one or two neutral countries will be granted shortly.

Stocks of Pig.—The stock of Cleveland pig-iron in the public warrant stores here stands at 30,519 tons, composed of 28,757 tons of No. 3 quality, and 1,762 tons of other descriptions of iron deliverable as standard. Since the beginning of the month the stock has been reduced by 2,697 tons, 2,933 tons of No. 3 having been withdrawn, and 236 tons of standard iron having been added.

Hematite Iron.—The position as regards East Coast hematite pig shows little alteration. There are no stocks to draw upon and the output is going into consumption as it is produced. Consumers are pressing for deliveries, and the expected early additional supply will be very welcome. Nos. 1, 2 and 3 stand at 122*s.* 6*d.* for home use, and for export the quotation is 140*s.* and upward.

Shipments of Pig-Iron.—Shipments of pig-iron from the port of Middlesbrough were certainly less than could be wished, but under the conditions prevailing they cannot be regarded as unsatisfactory. So far this month they are officially returned at 24,860 tons as compared with 38,389 tons to the same date last month, and 17,870 tons for the corresponding part of June last year.

Coke.—Supply of coke is by no means abundant, but promises to improve. The fixed maximum of 28*s.* at the ovens is still realised for average blastfurnace kinds, and up to 30*s.* 6*d.* at the ovens is asked for qualities low in phosphorus.

Foreign Ore.—There is little new business passing in foreign ore. Consumers are now carrying fairly large stocks, and have heavy supplies steadily coming in on running contracts, so that they were not disposed to buy. Imports to the Tees so far this month amount to no less than 177,003 tons. The market quotation for Rubio of 50 per cent. quality is 36*s.* ex-ship Tees, and sellers are quite prepared to do business at that figure on the assumption that the freight Bilbao-Middlesbrough is 17*s.*, which is the official figure, though vessels are being fixed at 19*s.* in the open market.

Manufactured Iron and Steel.—The finished iron and steel industries present no new features of moment. Manufacturers continue to be too busily absorbed with Government work, for which they are still pressed for delivery, to pay much attention to the numerous private inquiries in the market, and consequently ordinary commercial business is practically neglected. Quotations all round are very strong, and there are hints of likely further advance for some descriptions of finished iron. The following are among the principal market rates:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 11*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets (¼ diameter), 17*l.*; iron ship rivets (⅜ diameter), 18*l.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 10*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets (¾ diameter), 18*l.*; steel ship rivets (⅜ diameter), 19*l.*; steel sheets (singles), 18*l.* 10*s.*; steel sheets (doubles), 18*l.* 15*s.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and steel joists, 11*l.* 2*s.* 6*d.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—The outlook in the steam coal trade is somewhat unsatisfactory, as it has been almost impossible for colliery owners to meet their obligations after providing for the requirements of the Government, which have been exceptionally heavy. Recently outputs have become heavier, but there has been a pronounced shortage of tonnage. Buyers have been pursuing a waiting policy. As regards the French coal trade, slow progress has been made with arrangements for exports under the limitation of prices scheme, which may possibly have to be modified. Patent fuel and coke have been firm. The best Admiralty large steam coal has been to some extent nominal; secondary qualities have made 49*s.* to 50*s.*; Monmouthshire Black Veins, 49*s.* to 50*s.*; ordinary Western Valleys, 48*s.* to 49*s.*; Eastern Valleys, 45*s.* to 47*s.* 6*d.*; best bunker smalls, 29*s.* to 30*s.*; and cargo smalls, 20*s.* to 22*s.* 6*d.* per ton. In bituminous coal the best households have made 23*s.* to 24*s.* per ton at the pits; No. 3 Rhondda large, 49*s.* to 50*s.*; smalls, 32*s.* to 34*s.*; No. 2 Rhondda large, 38*s.* to 40*s.*; and No. 2 smalls, 24*s.* to 25*s.* per ton. The latest quotation for patent fuel has been 50*s.* to 51*s.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 65*s.*; good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Commercial Facilities.—It is stated that a mutual service and an interchange of commercial facilities has been decided on by South Wales industries, to take effect at the close of the war. The idea is to make use of the maximum power of coal and shipping for the benefit of international customers, and a great combine, with a capital of 100,000,000*l.*, is spoken of. At present information upon the subject is necessarily vague, and Lord Rhondda has declined at present to make any statement. There has been some Manchester and Liverpool buying of late of Consolidated Cambrian shares.

Western Trade Matters.—The directors of the Cardiff Channel Dry Docks and Pontoon Company, Limited, recommend a dividend for the past year at the rate of 8 per cent. per anum, carrying forward 112,031*l.*; the balance brought into the year's accounts from 1914–15 was 98,078*l.* The profits for the past five years have been as follow:—1912, 27,671*l.*; 1913, 32,002*l.*; 1914, 34,762*l.*; 1915, 34,353*l.*; and 1916, 38,945*l.* The dividend for 1912 was at the rate of 7 per cent. per annum; since then there has been a continuous 8 per cent. per annum.—The Maindy Shipping Company gives its shareholders a dividend of 20 per cent. for its first 11 months' trading, together with a further bonus of 2½ per cent.—Notwithstanding recent categorical denials, there have been persistent rumours associating the Consolidated Cambrian, Limited, with reported big deals among shipping companies.—In response to recent appeals, Welsh coal-miners considerably abridged their Whitsun holidays, upon the whole. No fewer than 85 per cent. of the Merthyr miners turned up to work, and in the Eastern Valleys pits were fully staffed; at Maesteg, of 5,515 men on the pay sheets, 977 were absent.—At the last meeting of the Newport Harbour Board, Mr. Alderman Mordey referred to a proposed increase in the gridiron dues so as to bring them up to a level with charges at Cardiff; Mr. Mordey stated that the Board had been losing money at the gridiron for many years. It was reported by Mr. Green that the dredging plant of the Board had been hired by the Newport Alexandra Docks Company as from June 19.—At the annual meeting of William Cory and Son, Limited, the chairman (Sir A. C. Cory Wright) said the company had secured high freights in consequence of the general shortage of shipping. At the present time the company and its allies held upwards of 1,000,000*l.* of Government securities and Treasury bills, and the Government had nine of their largest steamers on charter; this had involved the company, however, in a considerable expense, as it had been necessary to charter other steamers at high rates. Since the close of the financial year, two subsidiary companies had been formed, one called the Cory Collieries, Limited, to take over all the company's steamers, and the other to deal with the lighterage trade and take over the company's tugs and barges. A French company had, further, been formed for extending the company's business in France; it was proposed to rent a quay on the banks of the Seine at Rouen.—Measures are being taken to exempt men working at Cardiff docks from military service; the men thus exempted will be registered, and certificates of exemption will be granted by a Committee of the Board of Trade. A minimum number of tin-plate workers are to remain at the works in order to carry on the industry.—The Bristol Waterworks Company has purchased two factories and a paper mill at Cheddar in order to secure the water rights.

Mr. Llewelyn Llewelyn.—The doyen of South Wales mining engineers has passed away in the person of Mr. Llewelyn Llewelyn, of Newport, Monmouthshire, who died at his residence on Saturday last. The deceased gentleman, who was High Sheriff of the County of Monmouth in 1913, commenced his career with the Powell Duffryn Company, in Aberdare, Glamorganshire, and was later appointed to the managership of the old South Wales Coal Company. In 1880 he undertook some administrative work in Chile, and on his return, some four years later, acquired a controlling interest in the Abersychan Collieries, of which he later became sole owner, and of which he subsequently disposed to the Powell Tillery Company. A member of the South Wales Institute of Engineers, Mr. Llew. Llewelyn performed much important and thoroughly appreciated public work. He often represented the coalowners at important conferences, was Chairman of the Newport Harbour Commission and held several other posts of honour. He leaves six sons. Mr. Leonard Llewelyn is Mr. Lloyd George's chief assistant at the Ministry of Munitions, Mr. Ivor Llewelyn is the managing director of the United National Collieries, Mr. Ernest Llewelyn is consulting engineer to the firm of Messrs. Baldwin, Limited, Mr. Herbert Llewelyn is at the War Office, Capt. Frank Llewelyn is consulting engineer to the Ministry of Munitions in South Wales, and Lieut. Hedley Llewelyn is with the Grenadier Guards in France. The funeral took place on Tuesday.

CONTROL OF ITALIAN SHIPPING.—From a Report published by the Government Freight Commission appointed last February, the Italian Chamber of Commerce in London understands that 75 per cent. of the Italian cargo steamers have been requisitioned on behalf of various departments of the Government, and the remaining 25 per cent., which are also under the control of the Commission, have been detailed to furnish supplies for the factories which have been taken over by the Government for the manufacture of munitions, or, in the case of smaller ships, have been employed for the importation of phosphates. Passenger ships have been taken over at reduced freights for the import of grain and other necessaries. The Commission is also making use of sailing ships of adequate tonnage principally for the import of coal. These ships are managed by the owners on behalf of the Commission and are paid requisition rates. So far 87 sailing ships, of a total tonnage of 150,000, have been put on the list by the Commission. Owing to the cost of coal the Government have increased the tax on tickets on the State railways and have raised tariffs in certain instances. Private railways have raised fares, and subsidised steamship companies have increased the price of passages.

RAILWAY AND HIGHWAY SCHERZER ROLLER-LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C.E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 592.)

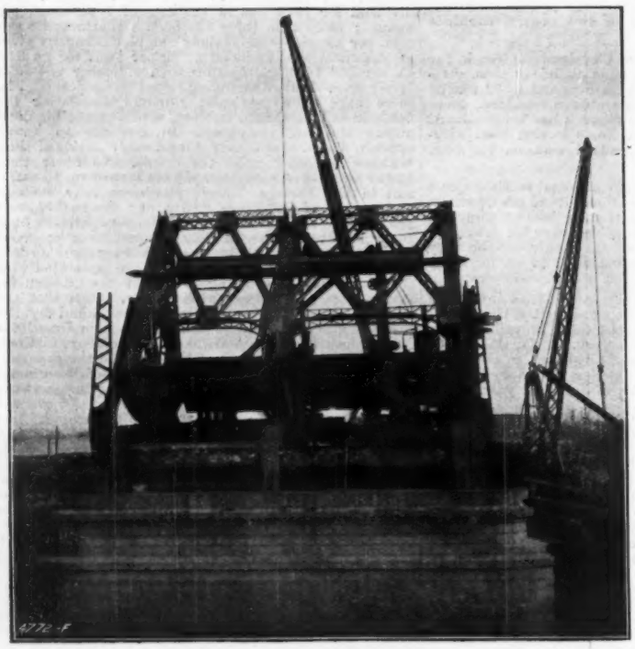

FIG. 5. ROLLING SEGMENT OF LIFT SPAN ERECTED, FEBRUARY 23, 1915.

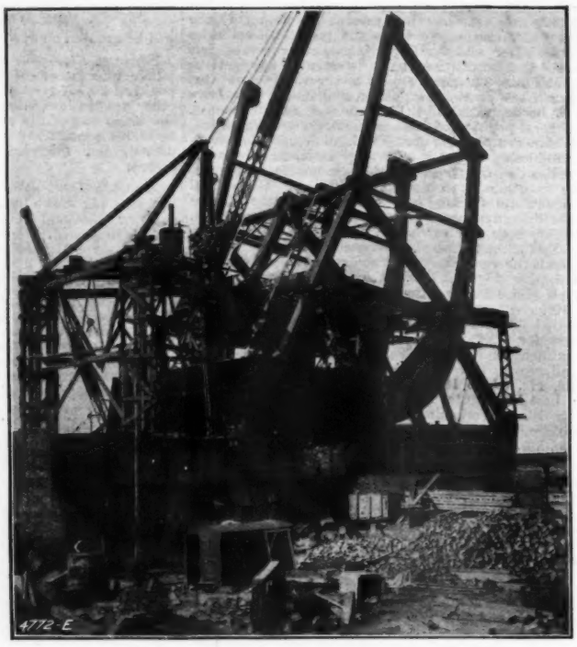

FIG. 6. LIFT SPAN, MAY 14, 1915.

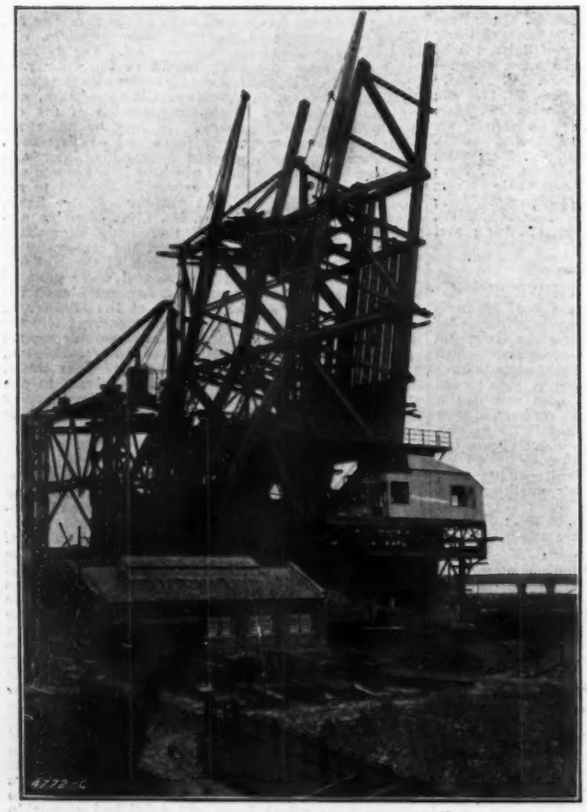

FIG. 7. UPPER PORTION OF LIFT SPAN IN PROGRESS, JULY 22, 1915.

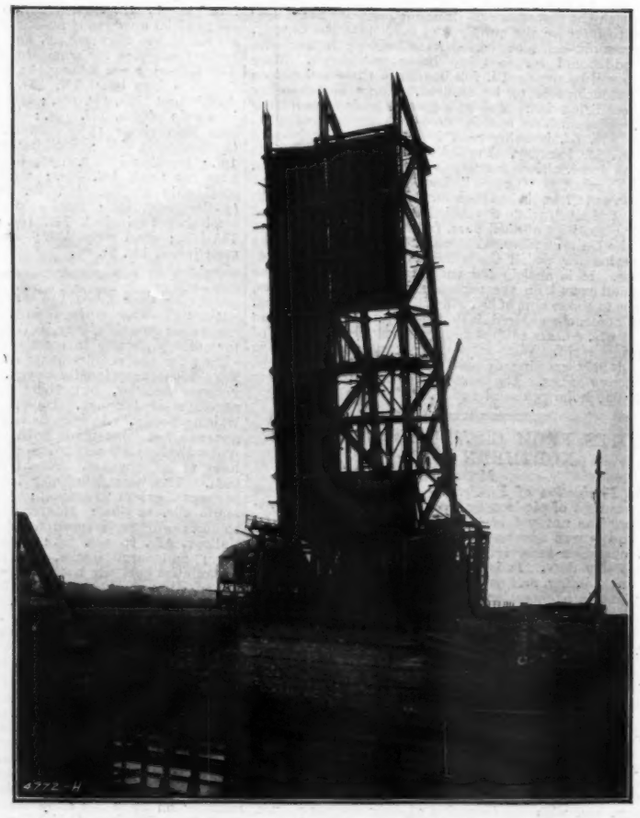

FIG. 8. LIFT SPAN NEARING COMPLETION, SEPTEMBER 24, 1915.

COMBINED RAILWAY AND HIGHWAY SCHERZER ROLLER-LIFT BRIDGE; GREAT CENTRAL RAILWAY.

MR. J. B. BALL, M. INST. C. E., ENGINEER; SIR WILLIAM ARROL AND CO., LIMITED, GLASGOW, CONTRACTORS.

(*For Description, see Page* 592.)

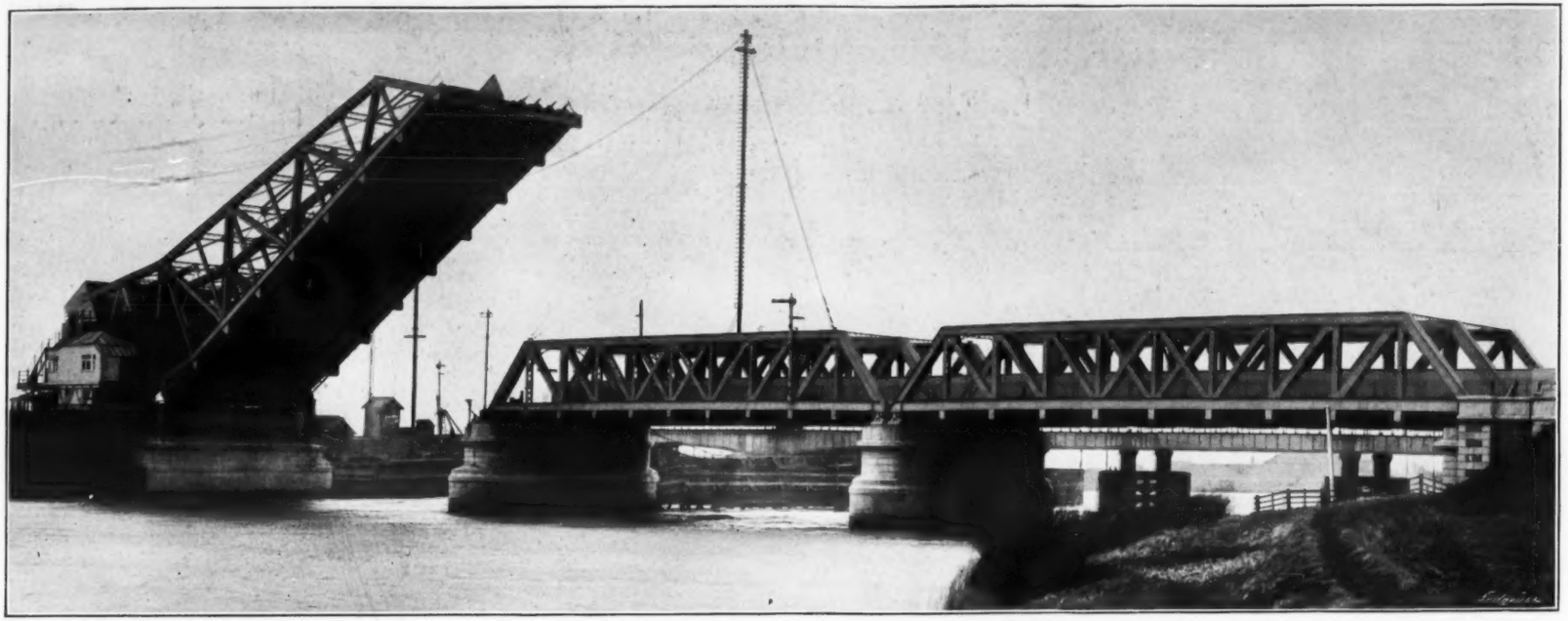

FIG. 1. THE BRIDGE COMPLETED; THE SCHERZER SPAN BEING RAISED.

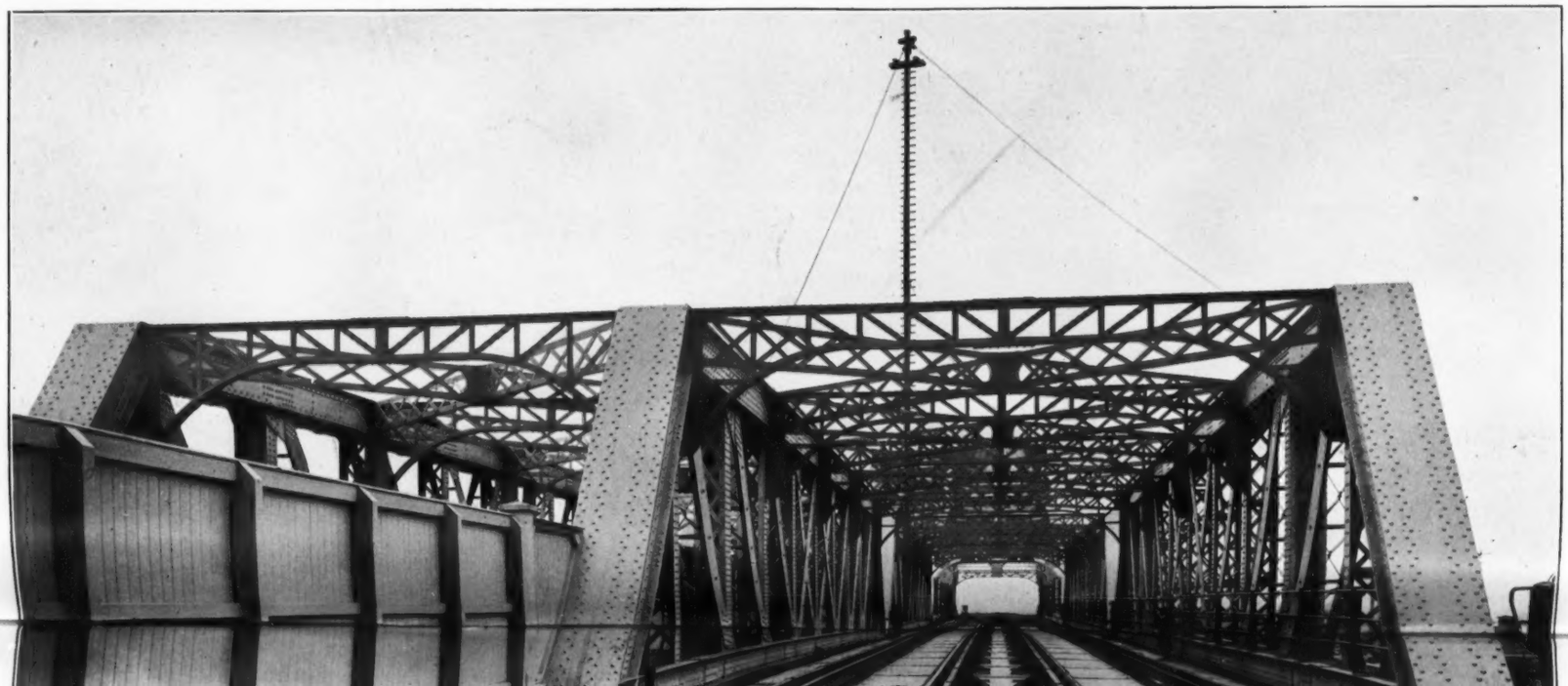

FIG. 2. VIEW ALONG BRIDGE, LOOKING TOWARDS SCHERZER LIFT SPAN.

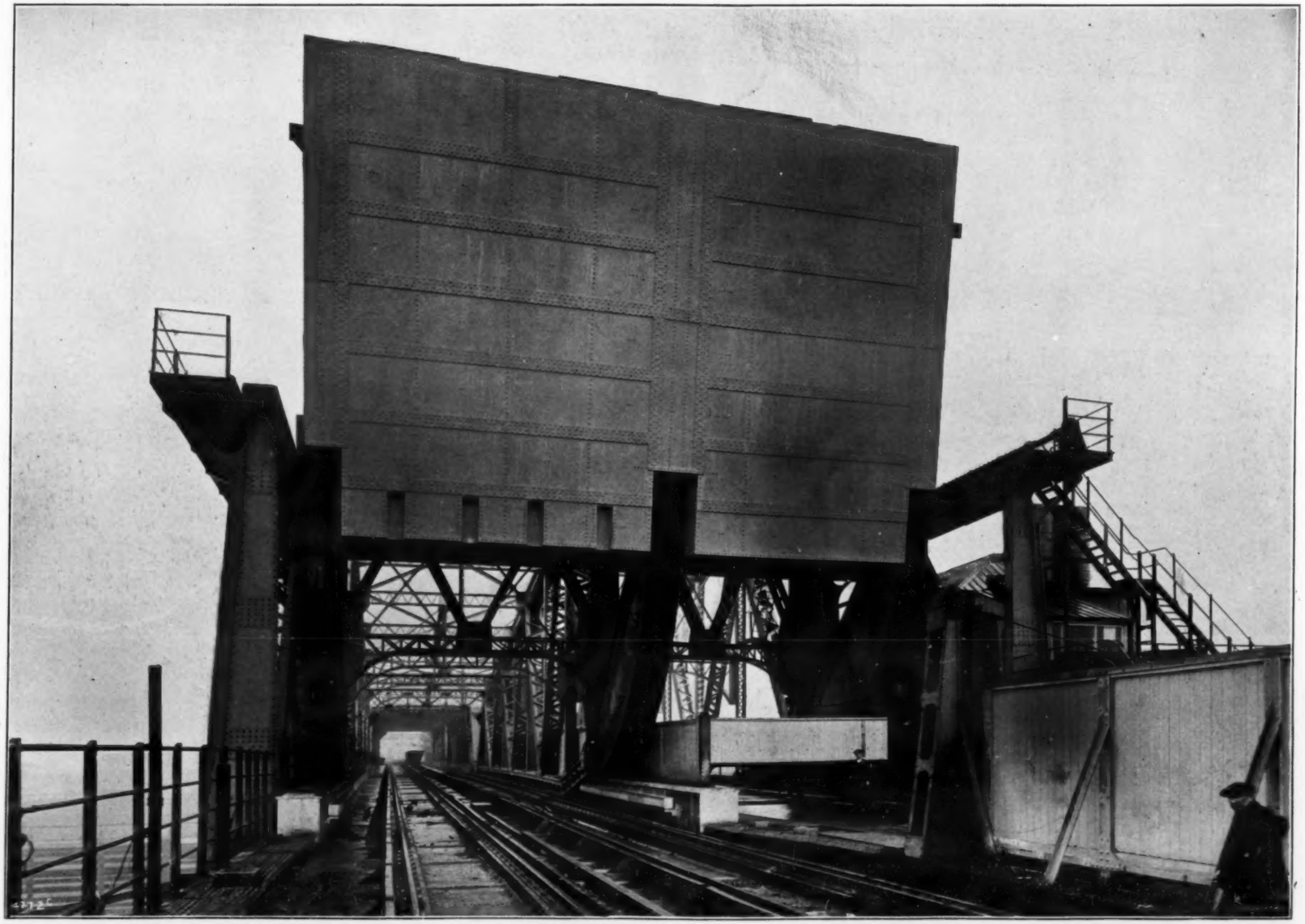

FIG. 3. VIEW OF SCHERZER ROLLING-LIFT SPAN, WITH COUNTERBALANCE WEIGHT.

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With a Two-Page Plate of the COMBINED RAILWAY AND HIGHWAY SCHERZER ROLLER-LIFT BRIDGE ON THE GREAT CENTRAL RAILWAY.

NOTICES OF MEETINGS.

ASSOCIATION OF SUPERVISING ELECTRICIANS.—Tuesday, June 27, at 7.30 p.m., at St. Bride's Institute, Bride's Lane, E.C. Annual general meeting.

THE ROYAL SOCIETY OF ARTS.—Thursday, June 29. A paper on "The Sikhs" will be read by Sirdar Daljit Singh, C.S.I., Member of the Council of the Secretary of State for India. The Right Hon. Austen Chamberlain, M.P., Secretary of State for India, will preside. The chair will be taken at 4.30 p.m.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, JUNE 23, 1916.

CIVIL ENGINEERING EMPLOYMENT IN THE FUTURE.

IN normal times civil engineers throughout the country would at this time of the year be actively employed in surveying and preparing plans in connection with improvement schemes to be submitted to Parliament next session. The necessary notices giving information to all concerned in such schemes require to be published before the end of November, and the plans deposited soon thereafter at St. Stephen's. November is fast approaching, and although the stress of war prevents a high degree of enterprise in civil engineering undertakings, particularly in view of the absence of available capital, there are other considerations of vital moment which ought to counterbalance any tendency to hesitancy or delay. We have written on this subject before, but the time is opportune for again enforcing the need for anticipating the utilisation of that great volume of labour which must be employed immediately upon liberation from the Army service after the declaration of peace. It is true that in many respects the places of those who have left their work for the fighting line are only temporarily occupied by female and unskilled labour, but the problem of absorbing quickly the men who return from the front upon the conclusion of war will be so great that hardship will result unless measures are taken in anticipation so that there may be immediate demand for a great excess of labour above the normal volume. Moreover, it is important that the maximum effort now being made in order to supply the munitions of war should be continued to ensure a quick recuperation of the exchequer of the country, public and private. Consequently it may be found expedient, in the interests of financial stability, to retain female and unskilled labour, even after the war, where the work done is quite satisfactory and profitable from the national standpoint. But skilled workers coming back from the front must at once be provided with suitable and remunerative work, particularly where such is conducive to the national end, and to this extent there must be redistribution of the unskilled labour now utilised. Thus, from every point of view it is of the utmost importance that there shall be ready openings for a large army of men accustomed to open-air life, full of that virility which has been engendered by the simple and strenuous life of the trenches, and eager for physical work of a remunerative character.

Civil engineering affords those openings which are necessary for a large proportion of the men now engaged in the open-air operations of war. Many men of the unemployable type had to join the Colours for their own good, from the point of view of physique if not of discipline. There are a great many young men who have willingly resigned their occupations, such as van-driving, shop-keeping, &c., which are more or less cul-de-sacs, with no possible line of betterment in well-doing. For such men incalculable advantage would accrue were it possible to place them in an occupation where the future prospects would be commensurate with the zeal and effort exercised. Public works would offer the necessary avenue for the employment of such labour, even if of a temporary character, until it became possible to redistribute the workers according to their ability. It is therefore incumbent upon public authorities and also upon railway, dock and other large corporations, to take account now of the prospective needs, and to make all preliminary arrangements so that work may be commenced, even in anticipation of the absolute necessities of the case, immediately on the declaration of peace, in order to create a demand for that labour of which there will be an abundant supply. We have written advisedly that such undertakings might even be in advance of the actual requirements, because the conditions justify this. But it may be urged that the financial situation does not permit such anticipatory measures. Here, however, the Government must afford assistance on the principle that it is better to advance loans to municipal authorities and to public corporations for the prosecution of undertakings of a profit-yielding character rather than to organise benevolent schemes for the help of men and their families who are unable at once to find employment. So long as the works conduce to the accumulation of wealth, loans, even at the high rate of interest now obtaining, are justifiable as an unavoidable expedient, and it would be well if the Local Government Board could see their way thus to encourage now the formulation of schemes of public improvement The making of surveys and the preparation of Parliamentary plans, of themselves, involve comparatively a small proportion of the expenditure.

That there are many schemes of great public utility awaiting execution it would be easy to prove. These, too, are just of a type to absorb all classes of workers who may return from the war and may find it difficult immediately to secure employment at their own trade. The case of London alone is sufficiently illustrative of this. To begin with, there are in progress immense extensions to the London Docks. The Port of London Authority, when instituted seven years ago under the chairmanship of Lord Devonport, very properly utilised their first two years for the elaboration of a comprehensive scheme of dock and warehouse extension, and since then great developments have been made; the addition to the length of wharfage completed or now in progress is four miles, and the warehouses are of a capacity 50 per cent. greater than before the advent of the new authority. Part of the work, however, has been held up owing to the war, and again we put forward the contention that to continue this restriction of labour, notably at the South Albert Dock, is false policy on the part of the Government, because at the conclusion of the war there will be such an accession of shipping traffic in the port that this new large dock will be required and there will still be insufficient accommodation for the increased traffic. But the Authority have other immense schemes prepared, notably for the construction of a North Albert Dock designed to meet all probable shipbuilding developments during the next 40 or 50 years. Thus the extension of the docks in London would absorb an enormous volume of labour.

But more is needed if the efficiency of the docks and the economy of the operations of those engaged in shipping and the commerce associated with it are to be satisfactory. Mr. Arthur Crow, F.R.I.B.A., in a paper read at the London Society on Monday, referred to this subject and put forward a plea for a comprehensive scheme of railway and road lines of communication, not only to relieve the existing traffic, but to ensure more rapid, and therefore more economical, transport facilities in the East End, and further to develop the transference of industrial undertakings to the unoccupied areas beyond the fringe of the Metropolis. The end of the war will release an enormous number of mechanically-propelled vehicles now used in Flanders and France, and if these are to be efficiently employed such arteries will become absolutely essential. Many Royal Commissions on London Traffic have agreed upon the necessity for such roads, but little or no action has been taken. Within the metropolitan area anyone would almost seem to have the right to erect buildings of great height for factory and other purposes, however narrow the thoroughfare and however congested the housing of the people. No doubt there are building laws, but no one can walk through the

streets adjacent to the docks without a feeling of extreme depression, due to the lack of control and to the unsatisfactory solution of the housing problem; indeed, there is no attempt at solution. It would be idle to arrange for great broad thoroughfares beyond the metropolitan fringe, in order that there might be a wide distribution of factories, if, within London, there were impossibly narrow necks throttling the traffic proceeding beyond. Obviously a suitable building line should be laid down in all thoroughfares, so that when new factories or tenements are erected there would be greater street width.

Mr. Crow indicated some of the schemes which ought to be promoted. These included an improved artery between the Euston-road, Canning Town, Dagenham, Grays, and Tilbury, with branches to the London and St. Katherine's Docks, and the riverside wharves of Wapping, Ratcliff, Poplar, Silvertown and Woolwich. The need for the improvement of the Victoria Dock-road, too, is admitted, and a high-level road has been provisionally agreed to. A by-pass road from the Beckton-road to the Ripple-road, avoiding East Ham and Barking, has been approved. The reconstruction of the iron bridge over Bow Creek, with improved approaches, is, he contended, a work not for postponement, but for construction immediately after the war. He thought also that the superfluous loop in the Creek should be removed by a short cut leading direct to the mouth of the creek; the land thus rendered available would form a useful site for an extension of the East India Dock. The time, too, has come for the construction of that great circular railway girdling Outer London, especially to the north, which would link up the North-Western Railway at Watford, the Midland at St. Albans, the Great Northern at Hatfield, and the Great Eastern at Broxbourne, whence the existing line from Epping to Ongar could be utilised, and a new branch effected with the Chelmsford and Southend lines between Romford and Brentford, proceeding thence from Upminster to Grays and Tilbury. The Victoria and Albert Docks could be connected to this line from Plaistow and through Canning Town, so that there would be no need to use the Metropolitan lines for the distribution of imports to, and the receipt of exports from, the great industrial areas in the north. The tube system, too, should be extended, and a regular comprehensive scheme arranged, so that there could be a further great development of that transference of factories from London to the outer rural districts. Already Letchford, Sudbury, Enfield, Tottenham, Barking, Dagenham and other places are becoming great industrial centres, encouraging the migration of works and workers from the crowded Metropolis. Everything should be done, and done at once, to encourage this very desirable development, because it means not only decreased charges for the ground and lower rates, greater area, which is conducive to industrial efficiency, but healthier and therefore more active workers, and the building up of a future generation of greater virility and wider intelligence due to the influences of environment.

ELECTROLYSIS FROM STRAY CURRENTS.

IT is almost forgotten in this country that the introduction of electric tramways, thirty and more years ago, was followed by serious complaints about electrolytic corrosion of underground pipes. Legislation fortunately stepped in at a relatively early stage and caused the removal of the source of the evil—the stray currents. Stringent regulations limiting the voltage drop were enforced; those regulations necessitated the adoption of better methods of bonding for the track return and the installation of negative return feeders. In America matters have not taken so satisfactory a development as in the United Kingdom and in most European States. In America electric tramways spread more rapidly and more recklessly. The law did not generally enforce measures to stop stray currents, though it admitted of raising claims for damage done by them; various cures were tried, and pipe drainage in particular has been relied upon. Pipe drainage means that the pipes and underground cables are connected with the rails or negative mains wherever the former tend to become positive to the return circuit. Bonding was also improved, of course; more recently, the adoption of insulating joints for pipes has become fairly common, and the situation has decidedly improved in general of late owing to the co-operation of various bodies. Yet the Bureau of Standards was, a few years ago, charged by Congress with an experimental investigation of "Electrolysis and its Mitigation." A special grant was made, and an instructive general report upon the subject (Technologic Paper No. 52, by Messrs. E. B. Rosa and B. McCollum) embodies suggestions which will probably guide Congress in legislation.

The title does not mention stray currents from tracks, but the report, of 173 pages, confines itself

Fig. 1. DRESSER COUPLING

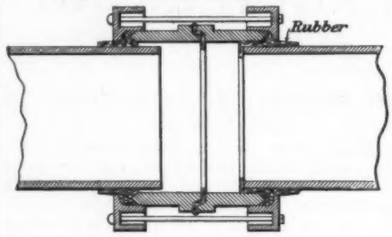


Fig. 2. WOOD STAVE JOINT; PENNSYLVANIA WATER Co.

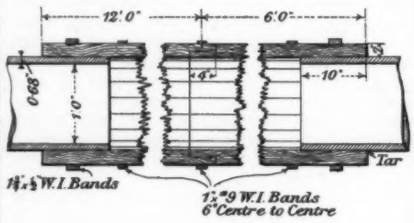


Fig. 3. INSULATING JOINT; METROPOLITAN WATER BOARD BOSTON.

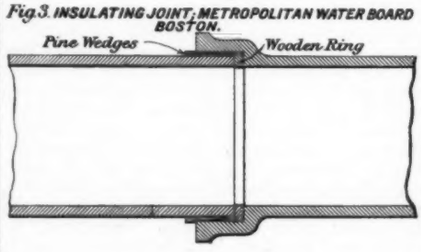
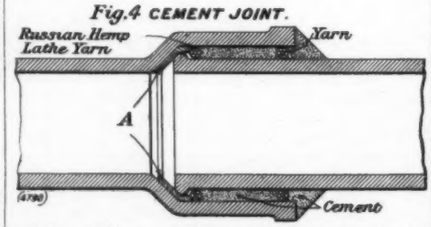


Fig. 4. CEMENT JOINT.



to that problem. Owing to the drop of potential in the railway return track portions remote from the power house will be at a potential above that of the earth, whilst the track potential near the power station will be below that of the earth. Currents therefore tend to flow from the track to the earth in the outlying districts, accumulating in the pipe lines and cables buried in this "negative area." Meeting with little resistance in the pipes, the current remains in them until the pipes are, in the "positive area" near the power station, at higher potential than the track, when they discharge back. The corrosion is not confined to so-called positive areas, however. Local features, high resistances across short gaps in joints, &c., will cause local leakage, and the various pipes in an area will not be equally endangered. By protecting one structure, other structures will be more endangered, unless the primary cause be stopped; that is the fundamental difficulty of all the cures which are not preventions. A slight corrosion in an exposed place may be very serious, of course; but even the average—a high average, it is true—destruction in a wet soil of about 20 lb. of iron and 75 lb. of lead per ampere per year deserves earnest attention. Cases have, moreover, been brought to the notice of the Bureau of lead pipes fused by the stray-current heat, and in ferro-concrete there is not only anodic corrosion, but also a cathodic softening of the concrete by a concentration of the alkali. The Bureau had discovered only one such case, in which salt was present in the concrete, whilst in other instances of corroded bridges, &c., stray currents were found innocent.

As regards methods of mitigation, the report discusses, largely on the strength of new experiments, surface insulation and protection of pipes by paint, dips, wrappings, chemical passivation (*e.g.*, by lime), cement coatings, cathodic protection (by boosters, buried pieces of zinc, &c.), conducting coatings, electric screens, favourable location of pipes with regard to the track, and insulating joints in pipes. Paints and wrappings are not non-absorbent, chemical protection is only temporary, boosting has the drawbacks of pipe drainage, and conducting coatings, once locally damaged, break down like paint; yet some of these measures, like the insulating joints, are acceptable as auxiliary aids. Details are given of trials of paints and of experiments on insulating joints of leadite, rubber, wood cement, &c. The form of the joint is found very important; we illustrate some of these joints in Figs. 1 to 4. With the socket and spigot type the current density becomes very high just under the edge of the socket; the butt (wood) joint of ¼ in. length showed a better current distribution, with long joints (5 in. and more) the maximum discharge intensity was relatively low; yet as the total current flow did not differ much in the three cases, a large number of short joints seem preferable to a few long ones. On the other hand, it is estimated that the following voltages would be safe for a life of 40 years in ½-in. cast-iron pipes: 0.147 volt for socket and spigot joints, 0.53 volt for ½-in. wood, 1.22 volts for 5-in. wood.

In one form of the Dresser coupling, Fig. 1, which is extensively used for gas mains, a sleeve rests with rubber packing on the two pipe ends and is subdivided by a ring of rubber insulation; the rubber is deteriorated by the sulphur in the gas, however, the leakage path is short, and the original high insulation resistances measured were found to have dropped to a few ohms in a few years. Yet the Dresser coupling is satisfactory for many purposes, especially in mains for natural gas, which is generally free from sulphur. In leadite joints the resistance went down from 2,174 ohms; *e.g.*, to 8 ohms in two months, and to 0.1 ohm in four years. Leadite, which is poured like lead, contains sulphur, which is converted into sulphuric acid in wet ground. Numerous modifications of wood joints are in use. Fig. 2 illustrates the type of the Pennsylvania Water Company; electrically it is particularly adapted for use in places where only one or a few joints are installed, possibly to meet high potential drops. A modification of this joint, with less substantial wood stavings wound with asphalted spiral steel tape, is less recommendable. The Metropolitan Water Board of Boston makes use of a very simple joint (Fig. 3), consisting of a ½-in. wooden liner which is built up of overlapping sections of wood, the ring formed being wound with canvas impregnated with paraffin; this ring prevents contact between the ends of the pipes. The wooden shapes are of clear white pine and are planed to fit the curvature and driven in by a special tool to obviate splintering. The white pine wedges beyond are able to stop any leaks at pressures up to about 75 lb.; to meet higher pressures the wood pores are closed by dipping the wood into red lead; iron bands may be clamped round the spigot end of the pipe. These joints are satisfactory apart from the short leakage path; their addition to old pipes would be expensive. Cement joints of the socket and spigot type require very careful making. In the form originally used by the Cambridge Gas Light Company the two pipe ends were in metallic contact. In the modification illustrated in Fig. 4, which is recommended by the Bureau,

the inner contact between the pipe ends is prevented by inserting a packing of rubber or fibre; a ring of hemp is then driven in with a caulking tool, and the cement filled in and fixed by another hemp ring. To make the leakage path as long as possible, it is further recommended to wrap the joint outside with several layers of tarred paper or to place the joint in a wooden trough filled with pitch.

The dangers of electric pipe drainage systems by negative boosters are now quite understood They necessarily increase the current carried by the pipes, and trouble is apt to develop on high-resistance joints and in unlooked for places of neighbouring structures. The drainage of underground structures tends to concentrate alkali at the surface of negative electrodes, which may be fatal to lead cables and pipes, though it would afford some protection to iron pipes. Hence in complicated city networks pipe drainage does not appear advisable to the Bureau. But they would drain lead cable systems by means of insulated feeders; that is to say, they would provide insulated feeders from a negative busbar to the track and to the pipes in such a way that the feeders have all the same resistance and take the minimum possible current from the pipes at all points. That would be preferable to placing a separate booster in each feeder; but it would still require constant supervision and alterations when track or pipe conditions were changed.

The only safe way of meeting the evil is to prevent leakage, and that is discussed under the heading of methods of mitigation applicable to railway negative returns. There are many methods, more or less thorough and efficient: alternating-current systems; double trolley (in use in Cincinnati) and underground conduit systems (good, but expensive, as we know in London); use of negative trolleys (which merely postpones the trouble), and periodic reversal of trolley polarity, which might answer if it did not complicate the operation; to reverse once only every 24 hours would benefit iron pipes, but not lead pipes, the Bureau considers. To ground the track and negative mains has recently been again proposed; the Bureau warns against it and also against uninsulated negative feeders. The question of insulated negative feeders with or without boosters and of three-wire systems, parallel or sectionalised, receives fuller attention; a good deal can be done by these methods, but there is not sufficient experience so far as regards three-wire systems.

We now come to regulations proposed. Those in force in various countries all concern over-all potentials and potential gradients between various points on the track. The Bureau would prefer to limit the actual potential drops on the earth or on pipe networks. The latter would certainly afford a more direct criterion of the danger; but the Bureau seems to suggest something indefinite and difficult of control in the place of definite, easily controllable observations, though it may be that higher potentials could then be permitted on tracks having high resistance to earth. In England the voltage drops between any two points of a railway system, near which underground metallic structures are laid, is limited to 7 volts, and the Board of Trade moves only on the complaint of interested parties. In Germany the limit is 2½ volts in city networks and 1 volt per kilometre on interurban lines. In England the maximum limit is determined from the average value for the half-hour of maximum load and from the maximum drop during this period, the mean of these two values being taken as the maximum voltage; the limit of current density is 9 amperes per square inch of rail cross-section. Finding that these rules—as well as the German rules—are not quite free from ambiguity, that the actual corrosion is more nearly proportional to the average day load than to a maximum short-period peak, and that in many interurban railways a limitation based upon a momentary maximum would be prohibitive, the Bureau proposes to limit the over-all voltage drop to 2 or 4 volts, and the gradients to 0.3 or 0.4 volt per 1,000 ft., the values to be based on averages for periods of not less than half-an-hour; potential drops on pipe systems should be limited roughly to half these figures. The 2 or 4 volts would approximately correspond to maximum drops of from 3 to 10 volts for short periods, and it is pointed out that excessive drops might be tolerated for periods of, say, 15 minutes. To facilitate the determination of these values, permanent potential wires should be installed, and as these wires would be in the interest of the "utility companies" directly concerned in the electrolysis problem, the expense of installing and maintaining them should be borne by all the utility companies. Metallic connection between underground metallic structures and the track the Bureau deprecates at points where the pipe might become negative to the track; that would make such connection undesirable in cities except for cable lines. On the other hand, inter-connection of intersecting or parallel tracks is recommended. Good bonding is, of course, desired, and also cross-bonding at intervals of 200 or 500 ft. of track. Exemptions from these rules might be granted, and the Bureau does not wish to prescribe the exact means by which observation of the regulations might be secured. The regulations should be framed in consultation with all the parties concerned, by the State authorities—not the Federal (United States) authorities. One may differ from some of the suggestions. But as the matter is to be settled by all the parties concerned, and as duties are to be imposed upon the utility companies as well as upon the railways, a fair and effective understanding may be arrived at

ECONOMIC COMPACT OF THE ALLIES.

GENERAL approval will be accorded to the conclusions, now officially announced, arrived at by the conference of representatives of the Allied Governments which met in Paris last week. The Allies, according to the official Memorandum, aimed at "giving practical expression to their solidarity of views and interests, and of proposing to their respective Governments the appropriate measures for realising this solidarity." The necessity for this procedure was established by the agreements prepared by the Central European Powers with the obvious object of establishing their domination over the production of the markets of the whole world, and of imposing on other countries "an intolerable yoke." The representatives of the Allied Governments do not so much propose retaliatory measures, as such arrangements as are requisite to "secure for themselves and for the whole of the markets of neutral countries full economic independence and respect for sound commercial practice, and, further, to facilitate the organisation on a permanent basis of their economic alliance." The measures recommended fall under three definite headings: those in connection with the conduct of the war; those for the period of commercial, industrial, agricultural and maritime reconstruction immediately after the war; and, finally, permanent measures of mutual assistance and collaboration among the Allies.

The measures for the war period recommended have reference to direct trading with the enemy, and here the aim is total prohibition of such trading. The undertakings owned or operated by enemy subjects in the territories of the Allies are to be sequestered or placed under control, and close supervision is to be given to trading with neutral countries from which export to enemy territories may take place. The aim obviously is that control organisations approved by the Allies shall be set up in neutral countries; otherwise supplies must be limited or be under the supervision of the consular officers of the Allies.

The transitory measures for the period when the reconstruction of Allied countries and their trade is in progress, immediately after the war, are concerned primarily with the providing of mutual help for the restoration of plant in connection with the winning of raw materials, and the operation of shipping, railways, industry and agriculture generally, while the "most-favoured-nation" treatment is to be denied to the enemy, and stringent measures are to be imposed for the conservation for the Allied countries of all natural resources. Dumping by the enemy is to be prohibited. The Allies, too, will determine by agreement, through diplomatic channels, the special conditions to be imposed on the ships of the enemy Powers, and also for the prevention of enemy subjects exercising in the Allies' territory certain industries or professions which concern national defence or economic independence.

Of greater interest and far-reaching effect are the proposals connected with permanent measures of mutual assistance and collaboration among the Allies. In this respect it may be said that the resolutions meet the fullest anticipations of those who consider that the Allied nations should rid themselves, as far as possible, of German trade and influence. Indeed, Mr. Hughes, the Prime Minister of Australia, who was a member of the Conference, and who is known to have advanced views on this subject, regards the proposals as of wide-reaching effect: "They lay down the basis of a sound and practicable permanent economic policy. Their potential effects are almost infinite. They indicate a way by which the great rivers of commerce can be diverted from those channels along which, before the war, Germany had with masterly cunning contrived to guide them to the great advantage of herself and the detriment of the Allies, to others controlled by the Allies which will distribute the benefits more evenly." The resolutions themselves recommend the taking of the necessary steps "without delay" to render the Allies independent of enemy countries "so far as regards the raw materials and manufactured articles essential to the normal development of their economic activities." The measures, too, are to be directed towards assuring the independence of the Allies, not only so far as concerns their sources of supply, but also as regards their financial, commercial, and maritime organisation. Each of the Allied countries is free to adopt such procedures to achieve these ends as may commend themselves. They may have recourse either to enterprises subsidised, directed, or controlled by the Governments themselves; to the grant of financial assistance for the encouragement of scientific and technical research and the development of national industries and resources; to customs duties or prohibitions of a temporary or permanent character; or to a combination of these different methods. The intention is that there should be new trade treaties between the Allies, mutual trade relations regarding direct and rapid and and sea transport services at low rates, and extended postal telegraphic and other communications. Technical delegates are to meet to draw up measures for the assimilation, as far as may be possible, of the laws governing patents, indications of origin, trade marks, literary and artistic copyright, and similar international relationships.

Of course, the resolutions cannot be brought into effect without the ratification of the Governments of the respective Allied countries, and, to whatever extent the Governments may agree to follow the lead laid down, there will be a general wish that action should be taken at once. As Mr. Hughes points out, the proposals are "mere empty words unless Great Britain takes immediate steps to give effect to them. The other Allies look to her to lead the way, they expect her to breathe into the dry bones of their agreement the breath of life." A great opportunity is undoubtedly presented for the adoption of very necessary reforms. The suggestions made, if carried into effect, will not only hasten the achievement of victory, and therefore of a lasting peace, but ensure a greater measure of equality amongst the nations of the world in regard to trading conditions than has obtained in the past.

THE LATE DR. JOHN EDSON SWEET.

IT is with much regret that we record the death of Professor J. E. Sweet, formerly of Cornell University. It is possible that many of our present readers in this country will not recall the name of John Edson Sweet until they are reminded that he was the designer of the "straight-line engine." Earlier in his career, however, he was often in England, and his writings appeared in our columns on many occasions; but that was over forty years ago; during recent years his age has rendered him less inclined to travel and his British friends have seen little of him. After a life full of work characterised by much originality, he died on the 8th of last month, at Syracuse, N.Y., at the age of 83, and his loss will be deeply felt in America.

Dr. Sweet's career furnishes an instance of a man starting in one direction and gravitating by successive steps into the path of life for which he was fitted by nature. He was first apprenticed to the

carpentry and joinery trade, and when his time had expired he went into an architect's office with the purpose of qualifying himself as a draughtsman, believing this to be necessary for successful carpentry work. The following winter found him in the office of Mr. C. O. Holyoke, an artist and an admirer of Ruskin, who taught him the principle of suiting the construction to the use, and thus attaining to forms which satisfy the sense of beauty and fitness. The training he got in this office left its trace on a great deal of his subsequent work, and influenced the teaching he gave to his students when occupied in professorial duties. However, carpentry and constructional drawing for buildings occupied Sweet for 10 years. In 1862, at the age of 30, he attended the great exhibition in London, spending also some months on the Continent. At this time he patented a nail-making machine, which was taken up by the Patent Nut and Bolt Company, of Birmingham, and he entered their employ to superintend its construction. He then returned to America, and for some years he was engaged in engineering work of various kinds, part of the time being spent with the firm of Sweet, Barnes and Co., of Syracuse. In 1867 he was again in Europe, at the Paris Exhibition, where he had some machines on view, notably a type-setter. From 1871 to 1873 he was mainly occupied in bridge building for Howard Soule, of Syracuse, and then came what was probably the most important step in his career, when he became Professor of Mechanical Engineering in the Sibley College of Mechanic Arts of Cornell University. At that time the academic teaching of mechanical engineering was in the experimental stage, and it was fortunate for the College that it was able to secure such a teacher. Of scholastic methods he was, of course, ignorant, and he never attempted to imitate other teachers. In his methods there was little organisation and less method, but he attracted students and contrived to convey to them the lessons he had learned for himself in a wide and miscellaneous experience. He was far in advance of the times in his enthusiasm for accuracy, and to this was added a correct perception of the fundamental principles of construction, so that he was able to give his students both knowledge and an enthusiasm for good work. His conception of art in design he also kept in the foreground of his teaching.

We have stated that in former years Dr. Sweet was a contributor to ENGINEERING. Amongst the most interesting of these contributions was a series of 18 articles bearing the title "Mechanical Refinements," which appeared in our eleventh, twelfth, thirteenth and fourteenth volumes, and which dealt with those niceties of mechanical design on which Dr. Sweet was so well qualified to give advice. It was in one of these articles—that published on page 51 of our fourteenth volume—that Dr. Sweet first described the "straight-line" engine, then (1872) in its experimental stage, while nine years later (see ENGINEERING, vol. xxxi., pages 298, 299 and 300) we illustrated the engine in its commercial form and reproduced a great part of a paper entitled "Friction as a Factor in Motive Power Expansion," contributed to the American Society of Mechanical Engineers, in which Dr. Sweet dealt at length with the principles upon which the design of the engine was based.

The straight-line engine was designed in 1871, and in 1879 Sweet left the College to engage in the manufacture of his engine at Syracuse. The Straight-Line Engine Company was formed in 1881, and started in a small way. In 1890 a large new workshop was built by the firm, and the business has always prospered since.

In 1880 Sweet took the important step of making the initial move for the establishment of the American Society of Mechanical Engineers, and four years later he became the President. In 1904 he was elected an Honorary Member, while in 1912 the Society commemorated his eightieth birthday by a dinner at its annual meeting. In 1914 he was awarded the John Fritz Medal for his "achievements in machine design and pioneer work in applying sound engineering principles to the construction and development of the high-speed steam engine." In the same year the University of Syracuse conferred upon him the degree of Doctor of Engineering.

Dr. Sweet had the gift of making friends and keeping them. Long after his professorial career had ended a number of his former students, both of Cornell and at the Straight-Line Engine Works, formed an association of "Professor Sweet's Boys," and year by year many of them came long distances to the annual dinner held on his birthday.

THE NATIONAL PHYSICAL LABORATORY IN 1915-16.

THE General Board of the National Physical Laboratory met on Tuesday last to receive the report of the Executive Committee for the year ended March 31, 1916. As President of the Royal Society, Sir J. J. Thomson, O.M., is now Chairman of the General Board. As in last year, the Laboratory at Teddington was not thrown open to visitors on this occasion, and the main features of last year's report are accentuated this June: suspension of some lines of general research in favour of many lines of special research; little private testing, but a strong increase in testing for Government departments; depletion of the Laboratory staff of old members, who have joined the Army or are "lent" to the Government, and yet a notable growth of the staff owing to the temporary appointment of new juniors and to the aid given by volunteer assistants; increase both in expenditure and income, with a small balance on the right side. The splendid organisation of a body like the National Physical Laboratory has proved its efficiency in many ways. When the Ministry of Munitions, the Munitions Inventions Department, and the Board of Inventions and Research were formed, the director, Dr. R. T. Glazebrook, C.B., F.R.S., was appointed Scientific Adviser on Physical Questions, and he has acted as chairman of the Instruments Committee and of the Gauges Sub-Committee on Munitions Supply. Mr. Sears, head of the Metrology Division, has organised a special staff for testing gauges for the manufacture of fuses and shells. The Privy Council Committee for Scientific and Industrial Research has made grants to the Laboratory for researches on optical glass and other branches of manufacture, for which the country was dependent on foreign sources. To cope with the heavy aeronautical work, two new buildings and two more air-channels have been erected; these buildings are close to the northern boundary of the grounds, and the approach through the adjoining land, utilised for the building operations, has been acquired, thanks to a donation by Sir Robert Hadfield, and will afford a more convenient general approach to the Laboratory.

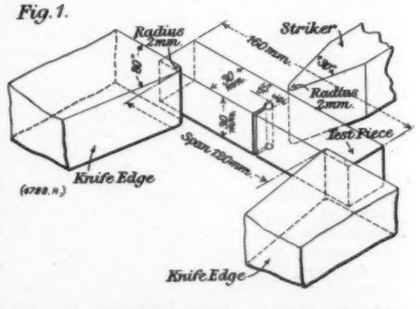
The Committee has to regret the death of two prominent members, Sir Andrew Noble and Sir Arthur Rücker. We mentioned last year* that one of the juniors had died of wounds received at Ypres. That death, in May, 1916, really fell in the Laboratory year under review, and there has been another victim under particularly sad conditions. Mr. Donald Ewen, M.Sc., of the Metallurgy Department, had served more than a year in France, and his release from service had been claimed by the Laboratory and already been granted by the War Office, when he was killed at Loos in October, 1915. On the other hand, Mr. G. H. Millar, of the National Tank staff, whom we reported as a prisoner at Döberitz, has been able to escape, and is now experimenting on seaplane floats. Thirty-eight members are in the Army, several others have temporarily been transferred to the Admiralty and other departments; 15 volunteer assistants and a considerable number of further employees, comprising 47 women, have temporarily been engaged, so that the staff has grown from 217 in April, 1915, to 337 in April, 1916. The salaries and wages have correspondingly risen from 29,623*l.* to 36,397*l.*, and the total expenditure from 39,572*l.* to 49,804*l.* (leaving out the shillings); the income has likewise grown, fortunately, from 39,653*l.* in 1915 to 51,372*l.*, so that there is a credit balance on the year's working of 1,568*l.*, bringing this balance up to 3,915*l.*; a liability of 1,661*l.* for the completion of the National Tank has to be set against this. The only direct donations of the past year are the 250*l.* given by Sir R. Hadfield (already referred to) and 200*l.* and 100*l.* given by the Institution of Mechanical Engineers for Alloys Research and by the Institution of Naval Architects for the Tank. It is pointed out, on the other side, that the systematic study of steels, the optical glass research, the study of refractories like carborundum, alundum, graphite, zirconia, and of the rare metals, and other problems, call for a technological laboratory on a large scale; the statement of work proposed alludes to these problems, which the Board will have to consider, though the war conditions will hardly admit of making much advance in this direction at present.

We begin our notice of the past year's work with the Engineering Department, of which Dr. T. E. Stanton, F.R.S., M.Inst.C.E., is Superintendent.

Engineering Department. Fatigue Resistance under Combined Stress (Dr. Stanton, Mr. R. G. C. Batson, A.M.Inst.C.E.).—Specimens from a mild steel, supplied by the British Association Committee on Complex Stress, and from a sample of a harder steel of the Laboratory, have been tested for combined bending and twisting on a new machine which is so designed that the ratio of the direct stress to the shear stress can be varied over the whole range from simple alternating torsion to simple alternating bending. The machine mentioned last year was modified so as to eliminate the bending stresses; the comparison of the results of last year (method of alternating torsion) with those of this year (alternating shear) shows, however, that this difficulty has not been successfully overcome, the new limiting ranges of shearing stress being appreciably higher than those of the former method. It is, on the other hand, satisfactory to note that the new limiting-stress ranges under simple alternating bending are identical with those formerly obtained on the old Wöhler machine (of which the present machine is a modification), although in the old machine the bending takes place in a plane rotating uniformly about the axis of the specimen, and in the new machine in a plane fixed relatively to the specimen.

Notched-Bar Impact Tests. Railway Carriage Couplings.—The three impact testing machines (the 20 ft.-ton, the 1,000 ft.-lb., and the smaller machine of Dr. F. Rogers) of the Laboratory are all of the same type, both the pendulum hammer and the anvil (of H shape) swinging about the same horizontal axis. The strikers and knife-edges are of the geometrical form suggested by Charpy. Fig. 1 illustrates the mounting, the dimensions marked being those adopted by the International Association for Testing Materials. The Teddington tests, made on two steels obtained from the Engineering Standards Committee, show once more that the standard dimensions are too large, because it would frequently be impossible to procure a specimen of those dimensions for further investigation of a part which has failed. The International Association had recognised this and had recommended the alternative use of specimens of one-third the maximum dimensions which are marked in Fig. 1. Dr. Stanton would prefer the one-third

Fig. 1.



scale as a general standard; there is the drawback, however, that it is not easy accurately to drill a hole of 4 mm. diameter at the bottom of the notch through a hard specimen. It had originally been intended that the impact specimens for the three machines should be 10 by 10 by 53 mm., 30 by 30 by 160 mm., and 90 by 90 by 480 mm. Owing to difficulties with the bridge piece (referred to lower down), the 90 by 90 mm. square bars were given up in favour of specimens

* See ENGINEERING, vol. xcix., page 707, June 25, 1915.

of 100 by 50 mm., and for *similar* specimens bars of 50 by 25 mm. and 25 by 125 mm. are used in the smaller machines. This is only for the scale effect investigation; the 30 by 30 mm. and 10 by 10 mm. are adhered to for commercial testing. In the ordinary Charpy machine the anvil is fixed, and the work done in the fracture is taken to be the difference between the initial and the final energies of the hammer, the work absorbed by the anvil being thus neglected. In the Laboratory machines the anvil also swings freely, and the work absorbed by the anvil is similarly deduced from its angular displacement. To determine this component, the anvil of the smallest machine was in some tests secured to a heavy base-plate and 16 carefully annealed specimens were tested, eight with the anvil free and eight with the anvil fixed. With the anvil fixed the work done (calculated from the initial and final positions of the hammer alone) was 5 per cent. greater than when the energy communicated to the anvil was taken into consideration; in this small machine, therefore, the fixing of the anvil does not much affect the results. Trouble has been experienced in making the bridge piece for carrying the knife-edges of the largest machine sufficiently strong; a satisfactory bridge piece, fixed by taper wedges (not bolts), has been found, however.

The railway carriage couplings (Messrs. Batson and A. Bailey, M.Sc.) tested for the India Office were of Yorkshire iron, high carbon steel, and nickel-chrome steel. The method was developed in consultation with Mr. H. M. Gresley (of the Great Northern Railway) and Mr. Seymour Tritton, and the India Office has decided upon the energy and number of blows to be given on a large impact machine, and the amount of extension which all the couplings should bear. The diagrams, Figs. 2 and 3, explain the arrangements. The coupling C is attached by its own connecting-pin to an eye-

Fig. 2.

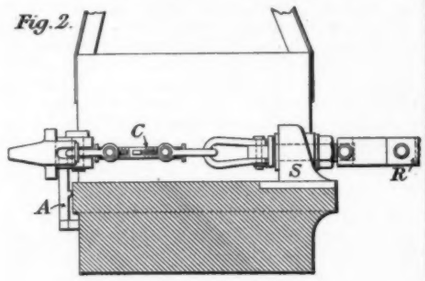
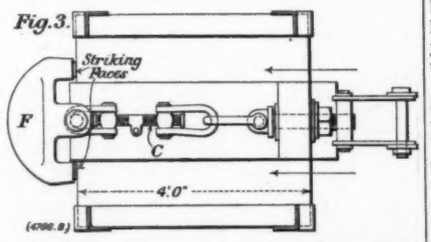


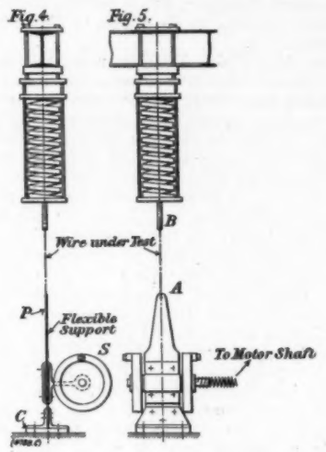
Fig. 3.



bolt, which is secured to the crosshead S of the anvil (weight 4½ tons). The other end of the bolt is screwed into a secondary crosshead, which is connected to a constant sliding frictional resistance R of 12 tons. The resistance to the blow of the hammer is therefore $12 + 4\frac{1}{2} = 16\frac{1}{2}$ tons. The free end of the coupling carries a crosshead F provided with hardened steel striking faces, which engage with corresponding steel faces on the hammer of the machine; the hammer, swinging in the direction of the arrow (Fig. 3) with a radius of 12 ft., delivers a blow usually of 5 ft.-tons. By means of the device A, consisting of a pair of levers and set-screws, an initial tension of 1½ tons is put on the coupling before the delivery of each blow. A coupling will stand about five blows, sometimes more than ten.

Resistance of Tension Members to Lateral Vibrations (Mr. J. H. Hyde, A.M. Inst. C.E.).—The screws of tension members of a structure attached to the pin joints of the frame by means of a screw connection (without universal joint) having been found to develop fatigue cracks at the bottom of the threads, the effect of the amplitude of the vibration on the endurance of loaded wires has been investigated by a novel method which is illustrated in the diagram, Figs. 4 and 5. A plate P is fixed to a rigid support C, and has attached to one side of it two bearings in which an unbalanced shaft S can be rotated, being driven through a spiral spring by an electric motor. The metal of the plate P is cut

Fig. 4. *Fig. 5.*



away until its upper point A, to which the wire under test is attached, will oscillate with an amplitude of about half an inch in a plane perpendicular to the shaft, the stress in the plate not reaching its elastic limit. At B, the wire—the test length being 8 or 10 ft.—is attached to a vertical rod controlled by a spiral spring, through which tension is put on the wire. The wire connections at A and B may be either rigid, a single pin joint, or a double pin joint, and the wire is screwed into the inner link of the joint and locked with a nut. The motor speed is gradually increased until the period of the disturbance due to the unbalanced shaft is approximately the same as the natural period of transverse vibrations of the wire under the given load; the amplitude of this vibration can be regulated (by the motor speed) within certain limits, from ¼ in. to about 3 in., and the number of vibrations required to break the wire is read off. It resulted that with universal joints both at A and B a load of one-third of the breaking load would be borne for an unlimited number of vibrations by a high-class wire material, but with only a single joint fracture, would take place after a few hours under one-sixth of the breaking load.

Resistance of Wood to Stress Reversals (Dr. Stanton).—The fatigue strength of the spruce wood wanted for aeroplane wing spars was determined by the Wöhler method, as no data on the subject could be found. The difficulty was to devise a chuck which would grip the specimen firmly for several hours without allowing it to work loose under the reversals of the bending movement. The specimens were selected with respect to similar distribution and thickness of the growth rings. When the range of stress was ± 2,510 lb. per sq. in. the specimen began to show cracks at 6 million alternations and failed after 16,860,000; with a range of ± 1,970 lb., cracks became visible at 16,250,000 alternations, and failure set in after 23,010,000 alternations; with ± 1,625 lb. per sq. in. no cracks appeared after 125,700,000 alternations, and the limiting resistance to alternating tension and compression of this specimen was therefore between 1,600 and 1,970 lb. per sq. in. Thus ± 1,870 lb. per sq. in. would be a safe range for that spruce, the ultimate strength of which was 6,800 lb. per sq. in., so that the safe limit of stress of this wood would only be one-quarter of the ultimate strength, whilst it is about one-third in the case of steel.

Hardness and Wear of Metals (Dr. Stanton, Mr. Batson).—The investigation undertaken for the Hardness Tests Research Committee of the Institution of Mechanical Engineers has been continued. In the first machine used the specimen was subjected to pure rolling abrasion. By this method the hardness of the surface gradually increases owing to the permanent deformation which the specimen undergoes, at a rate depending on the material, the effect being very noticeable in manganese steels, which owe their high wearing properties to this effect, according to Sir R. Hadfield. Comparative tests are further difficult by this method, because the abraded metal particles are rolled into the surface again. These features make the method unsuitable for pin joints, collars, gauges, &c. As a satisfactory abrasion test is unknown, successful attempts have been made to remove the abraded material by a strong air blast directed on the surfaces, and to avoid the vibrations set up in the specimen by uneven wear by adhering to the method of line contact between the specimen and the abrading surface. In the original Saniter test the specimen, a cylindrical pin of diameter d, was rotated (2,200 revolutions per minute) while a loaded ring of hard steel, of larger internal diameter, D, rested on it. The modification of the method called for a control of the movement of the wearing ring; as toothed gearing between the pin and ring would have been very expensive, the two parts were connected by an Oldham coupling, so as to describe a revolution in the same time with a relative sliding of the two surfaces amounting to π (D—d) per revolution. The machine has given satisfaction; the dust is not embedded in the wearing surfaces again, and the hardening due to the continuous, permanent strain is avoided, since the load is not sufficient to cause permanent deformation.

Cracks in Buildings (Dr. Stanton).—Three special micrometers, of Mr. Horace Darwin, were completed last August to measure the rate of growth of cracks in the buildings, as previously explained, of the Tower of London. On each side of a crack a hard steel peg is cemented into the masonry. One of the micrometers measures the relative movements of the two sides of the crack perpendicular to the wall, the other two the relative movements in the plane of the wall, in the horizontal and vertical directions. Weekly observations were planned, but fortnightly observations could only be taken. Only at one place the total movement in six months exceeded 0.01 in.; there were perceptible displacements, but irregular in character, and only in some cases of a progressive kind, the total displacement over the six months being smaller than the maximum recorded. Thus serious disturbances have not been detected. There is an indication of a tidal effect on one of the stations near the river front, however, and this is to be further investigated, though it will be difficult to separate tide, temperature, and other effects with so small movements.

Calibration of Testing Machines (Mr. C. Jakeman).—Applications having been made for calibrating tensile testing machines having a system of compound levers for measuring the load, a method has been devised, deadweight loading, always inconvenient, and single-lever methods being unsuitable. The Laboratory machines are of the single-lever type, and are calibrated in the following way. From a uniform bar of material a number of similar test pieces, three or two, are continuously cut of different sizes to cover the desired range of calibration. If these were numbered 1, 2, 3 in the order in which they were cut off, numbers 1 and 3 would be tested on the Laboratory machine, and number 2 on the machine to be calibrated. When a series of tests of bars of gradually reducing size are taken, it is sufficiently accurate generally to select alternate pieces in each machine; thus to test a machine from 10 to 50 tons, the bars would be 1*a* and 1*b* at 50 tons, 2*a* and 2*b* at 40 tons, 5*a* and 5*b* at 10 tons, and an extra pair, 6*a* and 6*b*, would generally be made to check one of the high points. Any changes in the quality of the material along the length of the bar and the differences of quality at the core and the surface of the bar would by this method be compensated for or eliminated to a large extent. Few materials were, however, found sufficiently homogeneous to give the required constancy of breaking load. The mild-steel bar used in the Laboratory has a breaking load of about 31 tons per sq. in., and consecutive test pieces rarely differ in strength by more than 1 part in 700. As regards the accuracy

attainable the area measurements cannot be expected to be exact within less than ½ or ¼ per cent. A greater error, of 1 per cent. even with a careful operator, is produced by the speed with which the last portion of the test is carried out, the inertia of the jockey weight generally leading to a reading slightly higher than the maximum being taken. One small 8-ton testing machine calibrated in this way showed an error of 3 per cent. at low loads, which increased progressively to 11 per cent. at the highest loads. The makers then overhauled the machine and had it re-tested, when the error did not exceed ¼ per cent. on any part of the scale.

Steam Joint Packings (Mr. Jakeman, Mr. Bailey).—Packings for steam jointings used largely to be of foreign manufacture, and it is difficult now to obtain efficient packings especially for superheated-steam pipes. Several samples have been tested in the apparatus for determining the blowing-out pressure of joints which Mr. Jakeman constructed in 1912.* The joint ring to be tested, ½ in. wide, is placed between the two parts of an annular steam chamber; the two parts are screwed together—not in the surfaces in contact with the ring, of course—and the joint is kept at constant pressure; the temperature of the steam is measured by a platinum thermometer. So far British makers have been successful in producing joint rings ranging from $\frac{1}{32}$ to ½ in. in thickness which will stand pressures of 250 lb. per sq. in. at a temperature of 1,000 or 1,100 deg. Fahr. without any signs of breaking down. The experiments are delicate. Much depends upon cutting the rings cleanly with the die or knife; when the surface is damaged in the slightest degree the blowing-out pressure may be very much reduced. Friction of the ring between the discs, which expand with the steam heat, also influences the results. Thick rings, consisting of several layers of asbestos and rubber, *e.g.*, may develop a leak because the rubber melts. Asbestos alone will stand high temperatures, but has no tensile strength. In successful joints the asbestos fibre seems to be thoroughly loaded with some sort of rubber solution, the whole compressed, and thus vulcanised.

Kapok and Cork Floats (Mr. Jakeman, Mr. Bailey).—The previous tests, carried out for the National Lifeboat Institution, had proved that the best floats were those containing kapok—a woolly fibre in which the seeds of so-called wool trees, eriodendron or bombax, are embedded—in a waterproof bag. Kapok itself rapidly absorbs moisture; if not otherwise, the moisture gains access through the stitch-holes of the water-proofing materials, and though some improvement has been realised in this respect, no really water-tight cover has yet been presented. Cork also absorbs moisture, but much more slowly. Some cork floats were tried of which the outer surface had been coated with a pitch preparation. The comparative weights supported by 1 lb. of kapok and 1 lb. of this cork were found to be as 2.4 : 1; the kapok lost 6.6 per cent. of its buoyancy in 48 hours, the cork only 1.4 per cent. The dry kapok is compressed for these purposes.

Aeronautics (Dr. Stanton, Messrs. L. Bairstow, A.R.C.Sc., F. H. Bramwell, E. F. Relf, J. L. Nayler, J. R. Pannell, A. Fage, E. W. Stedman, L. W. Bryant, T. Lavender, H. B. Irving, A. Landells, W. L. Cowley, L. F. G. Simmons, E. A. Griffiths, H. Levy, R. Jones; and the volunteer assistants, Dr. Norman Campbell, Dr. J. D. Coales, H. E. Collins, G. Pell, F. G. Woodford).—The large increase in the staff was connected with the provision of two additional air channels which the military and naval members of the Advisory Committee for Aeronautics, which controls the research work, considered indispensable. The two new buildings were speedily built by the Office of Works, Mr. Baines being the architect and Mr. Patey the engineer, and the channels erected. The two buildings lie parallel to one another to the north of the whirling-table house; the one building, 100 ft. by 40 ft., 35 ft. high, clear internal dimensions, contains only a 7-ft. channel, the other a 4-ft. channel, offices and pattern-makers' shop. A passage connects the two houses, and close to it the heating plant (hot water) and motor generator are installed. Current is taken at 3,000 volts alternating from the Twickenham and Teddington Electric Supply Company and converted into direct currents at 400 volts for the two channels, a Tirwill regulator keeping the voltage independent of the load on the generator. The lamps and small motors are on the 110-volt mains of the Laboratory. The channels embody a few improvements of the old channels; the aerodynamic balances of Mr. Bairstow and the apparatus could not all be made by the staff, which, so far, had chiefly relied on its own resources, and had partly to be obtained from the Cambridge Scientific Instrument Company, which has also supplied one of these balances to the School of Technology, at Boston U.S.A.

The Aeronautics Division now possesses two 7-ft. channels, two 4-ft. channels, one 3-ft. channel, a whirling area of 60 ft. diameter, and a water channel for obtaining photographic records of the flow of fluids. Other air channels for manufacturers of aircraft are under construction. The manifold problems under investigation comprise the effect of the fin area of airship models on the restoring couples which follow a displacement; the stability of an airship involves very complex problems. The stability and equilibrium of kite-balloons likewise offer considerable difficulties; the kite-wire introduces constraints of a character not investigated in connection with airships and aeroplanes. These experiments are conducted in connection with the full-scale experiments of the Admiralty. In addition to experiments on special aerofoils it is being further investigated what modifications the wings of an aeroplane require in the case of a machine which is to fly at high speed and to alight—within a fighting area—at a low speed. Some of these experiments can only be made in the largest channel; in general, however, the results obtained in the different channels differ little from one another. A great number of experiments have been made on models of complete aeroplanes and seaplanes; as the size of the plane increases, the air-forces relative to the pilot's strength increase, so that the balancing of the control surface has to be carefully examined. Predictions from the models are, however, fully justified by the tests on completed aeroplanes,. The form of aeroplane bodies, the disposition of guns, and the special duties of the machines have also been studied. The mathematical analysis has been extended to the examination of the stability in circling flight, horizontal or spiral; there is some interaction between the longitudinal and lateral motions which requires further investigation. As regards propellers, interference between the propeller and the aeroplane body has been investigated in the 4-ft. channel, and a suitable balance for such measurements in the 7-ft. channel is being constructed. The efficiency of radiators for aeroplanes and the resistance and stability of aerial bombs are other problems which are being dealt with.

Road Board Laboratory (Mr. Batson).—The research work on model roads was suspended after a few additional tests, but mechanical tests of stones (49 varieties) and granite setts for road construction and of bituminous sand carpets (specific gravity, percentage of voids, absorption of water and impact tests) have been continued. We noticed last year* the series of endurance tests made on asphalt carpets laid on concrete foundations, the series being numbered V. to IX. inclusive; and we described the method. The additional series are X. to XII. Road X. was like IX., a different grading of sand being used, however; it failed, apparently because a few sections had insufficiently consolidated. Road XI., also 1½ in. bituminous sand carpet (residual bitumen from asphaltic petroleum), failed for various reasons, one of them being that there was not sufficient bitumen (12 per cent.) for the class of sand used. Road XII., of the same type as XI., but containing more bitumen (14 per cent.) a different sand grading and more filler, stood the test very well; it was laid at a temperature of 325 to 415 deg. Fahr., whilst XI. had been laid at 200 to 260 deg. Fahr.

(To be continued.)

IMPERIAL AND INTERNATIONAL TRADING CONDITIONS: —ERRATUM.—We regret that, in the concluding sentence of the article on this subject in last week's issue, we gave the British imports from Germany as 167 million sterling; this figure should have been 56 million.

* See ENGINEERING, vol. xcv., page 848, June 30, 1913.

* See ENGINEERING, vol. xcix, page 708.

NOTES.

THE DEVELOPMENT OF CHINA.

THE conditions which in mediæval Europe hampered commerce and manufacture still subsist in China. This country is said to have made excellent roads two thousand years ago, but to have executed no repairs since. As a consequence, it is not unknown for a mule to be suffocated in the mud during the rains. The inhabitants, accordingly, remain as a whole poor, in spite of their extraordinary industry. The country is, however, so rich in natural resources that the extension of railways now in progress will lead to the creation of wealth on a vast scale. At present about 4,000 miles are open, and much more is under construction. The cost has, however, been increased by the necessity of bribery. According to Mr. S. J. Powell, A.M.I.C.E., had the Indian system been in vogue, in which every projected line has to submit an itemised estimate of its cost, not a mile would have been constructed in China, as much of the expenditure would be of a kind of which details could not in decency be made public. Mr. Powell strongly advocates the construction of narrow-gauge feeder lines, which, he states, would cost only about 800*l.* to 1,000*l.* per mile, as compared with 10,000*l.* a mile for standard gauge track. These lines would be laid to a 3 ft. or 2 ft. 6 in. gauge alongside the existing roads. He proposes that two or three should connect the rich pastoral district north of the Great Wall with the line along the coast of the Gulf of Pechili. Work on a similar scale should also be carried out in Northern and Southern Shensi. A line from Wuhu to Shanghai would capture the existing river traffic via Chinkiang, which is carried on under great difficulties. Mr. Powell also states that there is much room for improvement in the present methods of distributing goods at Shanghai, Tientsin and Hankow. Large quantities are carried up over the foreshore to store, and then back again when dispatched further inland. By depositing the goods in bonded warehouses erected on the wharves this double labour would be avoided. Much might also be done, Mr. Powell states, to improve river transportation. The present difficulties are such that even with craft specially designed for the purpose the cost of carriage is as much as 10 cents per ton-mile.

SHIPBUILDING PROGRESS IN CANADA.

It was appropriate that the Prime Minister of the Dominion of Canada should be present at, and that Lady Borden should perform, the christening ceremony of the first important mercantile ship launched by the new establishment at Montreal of the Canadian Vickers, Limited, which is essentially a Canadian concern,as this event signalized an important stage in the development of shipbuilding industry in the Dominion, which is so much desired not only by the Parliament but by the people. The vessel launched, too, had in itself a significance, as she was an ice-breaking steamship built for use in Canadian waters, and owes her name, J. D. Hazen, to the Minister of Marine and Fisheries. The vessel is not large as ships go, but embodies in her design many interesting features. The length over all is 292 ft., the length between perpendiculars 275 ft., the breadth moulded 57 ft. 6 in., and the depth moulded to upper deck, 23 ft. Her engines are specially powerful, being of 8,000 indicated horse-power, in order to drive her through the heavy ice-floes and to give a speed of 16 knots. She is also of exceptionally strong construction, but as we hope later to give fuller details, we content ourselves here with a reference to the significance of the event. The Canadian establishment in which the vessel was built, and which we illustrated a year ago, has been exceptionally busy on the building of ships for the Navy and munition work, but at the same time it has carried out its mercantile programme, which includes not only the ice-breaker but the largest hopper dredger which has yet been purchased in Canada and very extensive docking and repair operations. More work is being undertaken. It is true that at many other ports, for instance Port Arthur, Collingwood, Bridgeburg, Toronto, Owen Sound and Hamilton, merchant ships have been built for some time, but comparatively few of the ships are for salt-water

traffic, most being for the Lakes, where British and foreign competition does not apply to the same extent as with vessels built on the seaboard or on the St. Lawrence. The Canadians very properly hope that when peace comes there will be a very considerable accession in the Dominion to the number of immigrants with shipbuilding experience, and that there will be a consequent great stimulus to the shipbuilding trade.

Seaweeds, Kelp, Potash and Iodine.

Seaweeds have been used as manure from times immemorial, and their ashes or kelp have for generations been prepared for industrial purposes. A hundred years ago the Scottish and Irish kelp was still counted as a source of alkali for glass-making, and of iodine for chemical manufacture. During late decades the kelp industry has quite languished, however, in spite of many attempts to revive it, and there has been more literature on the subject than industry. That this is partly due to the total want of organisation and to the primitive methods applied here is shown by the fact that the United States Department of Agriculture considers the seaweeds of the Pacific—which, it must be granted, are richer in alkali and iodine than those of the North Sea—a profitable raw material, and something might possibly be accomplished on our coasts. The problem was ably discussed by Mr. James Hendrick, B.Sc., before the Edinburgh Section of the Society of Chemical Industry in April last (see Journal of the Society, May 31, 1916). The seaweeds in question, which Mr. Hendrick studied, are of the genus fucus—tangs growing between tide-marks—and of the genus laminaria — tangles, or drift weed, growing in shallow water on ground which is always or mostly covered by water. The tangle consists of a stem or stripe, which attaches itself to a stone, and the frond or leaf; the stem, sometimes distinguished as tangle proper, is richer in salts than the frond. The fucus are much poorer in ashes than the laminaria, and have a low value even as manures. In the laminaria Mr. Hendrick finds at least 75 per cent. of water. The dry weight may contain 35 per cent. of ashes, comprising 12 or 15 per cent. of potash, 8 of soda, and 0.8 per cent. of iodine, especially in the stems, as mentioned. These percentages are not low, though they do not come up to the 47 per cent. of potash observed in the giant kelps (the name is used for the seaweeds there) of the Pacific; but they fluctuate very much in different seaweeds, and they were only realised in laboratory tests of carefully-prepared samples. In Scotland and Ireland the weeds are dried on or near the beach where they are found, and then burnt in open fires on the ground or on a rough hearth of stones. The weeds always contain the shell-sand of the beach, which is undesirable and directly injurious, because the silica and lime combine with the alkali during the subsequent calcination to insoluble compounds, and some of the soluble salts are leached out of the weeds while they are drying in the open. Mr. Hendrick investigated these features. He found that potash, in particular, is washed out of the drying plant, while the temperature of the burning had less influence than he had expected. It is generally advised to avoid a fierce fire in kelp-making; in the absence of shells and sand, high temperature would do little harm, but when Mr. Hendrick placed a mixture of dry seaweed and shell sand into a red-hot muffle, a serious deficiency, especially of iodine, was noticed. In the United States the seaweed is collected *in situ* from special barges, and dried by steam. The weeds are, therefore, purer, and the natural lixiviation losses are avoided; the weeds are usually reduced to pulp for making manure, when the iodine is lost, of course. Mr. Hendrick also tried leaching the fresh undried tangles with water. A kind of cold diffusion process did not give satisfaction; the tangles were sliced as in sugar extraction from beetroot. He then reduced the weed to a pulp by means of superheated steam at 150 deg. Cent., placed the pulp in bags and squeezed the bags, and washed the pulp with water. This extraction was quantitatively satisfactory, but the liquid was opalescent and turbid, and contained many organic compounds which prevented the alkali from crystallising. The iodine could be liberated in a fairly purely state, but the potash looked too impure to fetch a fair price. Mr. W. G. O'Beirne questioned the purity of the iodine, while confirming Mr. Hendrick as to most of the other points. A company that Mr. O'Beirne was connected with spent thousands at Tiree, North Uist and Clydebank, on experimenting with seaweeds, also for the object of utilising the organic products, so far with very little success.

LITERATURE.

Industrial and Manufacturing Chemistry. Vol. I.: *Organic.* A Practical Treatise by Geoffrey Martin, Ph.D., D.Sc., F.C.S., assisted by specialists. Second Edition, revised and enlarged. London: Crosby Lockwood and Son. [Price 21s. net.]

This work, encyclopædic in character, is the second edition of a treatise that appeared about two years ago. The quick demand for a new edition affords welcome evidence of the existence of a class who desire more than a superficial acquaintance with the *rationale* of our chemical industries and manufactures, and of the satisfactory manner in which Dr. Martin and his coadjutors have catered for their requirements. A passage in the preface of the first edition stated that the object of the editor and his assistant staff was to cover the whole range of subjects that interest the industrial chemist and manufacturer in such a way that the work might meet the requirements of all business and practical men, "of manufacturers, consulting chemists, chemical engineers, patent workers, inventors, technical lawyers, students in technical institutions, lecturers on technology, fire insurance inspectors, and others." Truly an ambitious project, and a motley crowd of patrons to be satisfied. The Editor is to be congratulated on his deserved success, which we hope will be repeated in the enlarged edition. The ground that it is attempted to cover is too large to be exhaustively treated in a single volume, and those actively engaged in a special branch of manufacturing chemistry would go to other sources for detailed information; but no small service is rendered by presenting concise and critical summaries of what ingenuity and skill have achieved in so many various directions. Comprehensive monographs, with their abundant detail, are not without their disadvantages for some of the classes here considered.

Naturally the success depends in a great measure on the selection of the experts who are qualified by their knowledge and experience to speak with authority on this range of subjects. The day has long since passed when one man, however active and eminent, "could keep abreast of recent advances in the different branches." For similar reasons, no one reviewer, however omniscient, could deal adequately with the merits or the deficiencies of the work of the several specialists who have contributed to the 23 sections into which the book is divided. We must content ourselves with the briefest possible enumeration, without attempting any entry into details. At the same time, as a general remark applying to the whole, we would express our conviction that, within carefully-considered limits, the work is thorough and comprehensive. The length of the various articles —always a difficult matter to decide when many contributors collaborate—is apparently determined by the importance of the subject; historical references are made to contribute to the interest, and the space given to diagrams and illustrations is generous. In many instances, too, there may be noticed a suggestiveness in reference to some minor industries, and the possible utilisation of by-products, that should attract young chemists by the promise of substantial rewards that would follow successful development. Full literary references are prefaced to each article, and these must prove a valuable help to those needing wider technical information. The Editor suggests that the account of literature relating to chemical technology in its organic branches is the most complete ever published in English, and he may easily be correct. Add to this advantage frequent allusion to patents and many interesting statistics concerning prices, the value of imports and exports of the various commodities treated, and some of the grounds that have contributed to the early success of the volume will be appreciated.

The oil, fat, varnish, and soap industry, occupying one-fifth of the whole treatise, is the work of several hands, and the combination is very successful. Mr. C. Ainsworth Mitchell deals with mineral oils and lubricants, with the examination and testing of fatty oils, and the treatment and analyses of essential oils. In this last section reference might have been made to the work of Professor Wallach. To Mr. Newton Friend is entrusted the section on animal and vegetable oils and fats, including the manufacture of varnish, enamels, oil-cloth, and linoleum. The account of the milk, butter, and cheese industry, which might have formed a section by itself, is the work of Dr. Goodwin, while the details of margarine manufacture falls to the competent hands of the Editor, who is also responsible for the remaining subdivisions, which include the mineral waxes, asphalt and bitumen, industrial casein, candle-making materials, soap, glycerol, and synthetic perfumes. These names do not exhaust the list of contributing authors. Dr. Druce Lauder and Mr. A. J. Carriecr deal adequately with the sugar and cellulose industries respectively. Dr. H. J. S. Sands writes on dyes and their applications to colour-printing, and Mr. Law on tanning; while Mr. W. M. Barbour is responsible for the article on modern explosives, a subject that has acquired such overwhelming importance since the appearance of the first edition. The section of fermentation industries, one that will well repay careful study, is the joint product of the Editor in collaboration with Drs. Slator, Griffiths, and Stephens. In addition to a good account of enzymes and ferments, there are excellent descriptions and illustrations of machinery designed on a commercial scale for yeast culture, and of distilling and brewing plant. The article on continuous distillation and rectification is very thorough and practical. On the other hand, the chapter on vinegar, lactic acid, and butyric acid might have been extended. The manufacture of methyl alchool and acetic acid is described under "wood-distilling industries."

Necessarily many of the sections tracing the processes followed in smaller trades and industries are short, but the treatment is not perfunctory. Starch, gum, ink, glue, turpentine, aliphatic chemicals, each claim attention. These are mainly the work of the Editor. Of particular excellence among the shorter articles is one on acetylene, by Mr. F. B. Gatehouse, the Editor of the *Acetylene Lighting and Welding Journal.*

The additions to the new edition include some account of the hydrogenation of fats, a product that is absorbed mainly in soap-making, as a recent law-suit reminds us, but probably hardened cottonseed oil and whale oil enter largely into the composition of margarine, though no reference is made to such employment. The manufacture of milk, sugar, maize, and arrowroot starch is outlined in this edition, the first-mentioned being used in brewing, as it is not fermentable by ordinary yeast, and remains an unchanged carbohydrate in the finished product. To judge from the pagination, the chapter on synthetic rubber is new matter. Here the information is conveyed almost entirely by chemical symbols that will be decipherable only by the initiated. Considering the interest attaching to this subject, and the frantic efforts that have been made to produce either a true synthetic rubber or an efficient substitute at a low price, it would have been well to have translated the results into a more popular language. Various methods of obtaining butadiene and its homologues from butyl alcohol, aldehyde, phenol, &c., are given, and the processes pursued in polymerising are explained; but, perhaps, of even more importance to those interested are the references to the patents. To what extent the commercial production has proceeded is not clear, but it is stated that the cost of producing a pound of rubber from the fermentation of maize or potatoes should not exceed 4d. to 6d. There is, however, no evidence that it has been produced at that price, which at the present quotation for plantation rubber would allow an ample margin of profit.

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics, writing in *The Board of Trade Labour Gazette*, states that employment in May continued at a very high level in all the industries directly affected by the requirements of the forces; in other industries it was good on the whole. The calling to the Colours of men of military age accentuated the shortage of labour, and the substitution of women required to be carried out to a much greater degree than had hitherto been accomplished.

Compared with a year ago, despite the substitution of women, there was a decline in the number of persons employed, but for those still in industry employment was better.

The wage changes reported as taking effect in May, all being increases, affected over 370,000 work-people, and resulted in a total increase of about 31,000*l.* per week. The principal bodies of workpeople affected were 130,000 coal-miners, including 120,000 in Durham, 64,000 woollen and worsted operatives in Yorkshire, 40,000 pottery workers in North Staffordshire, and 46,000 men in engineering works, principally in Yorkshire and Lancashire.

The number of trade disputes beginning in May was 41, and the total number of workpeople involved in all disputes in progress was 30,439, as compared with 54,656 in the previous month and 51,575 in May, 1915. The estimated total aggregate duration of all disputes during the month was 307,400 working days, as compared with 654,600 in April, 1916, and 246,700 in May, 1915.

The average weekly number of vacancies notified to all Labour Exchanges for the four weeks ended May 12 was 37,717, as compared with 38,734 in the previous five weeks, and with 36,055 in the four weeks ended May 14, 1915. The average weekly number of vacancies filled for the same periods was 28,661, 29,507 and 25,016 respectively.

Retail food prices in the United Kingdom on June 1 were higher than on May 1 by about 2½ per cent. As compared with June 1, 1915, retail food prices showed an average increase of 20 per cent. Taking the country as a whole, and making allowance for the relative importance of the various articles in working-class household expenditure, the average increase in the retail prices of food since the beginning of the war may be put at 59 per cent., which is reduced to 53 per cent. if the increase in the duty on tea and on sugar is deducted. These figures relate to food only. Rents generally are no higher than before the war. It may be estimated that the average increase in the cost of living of the working-classes, taking food, rent, clothing, fuel, light, &c., into consideration, between July, 1914, and the present time is about 40 per cent.

A further rise of nearly 10 per cent. was recorded in April in the general level of food prices in Berlin, the index number of the total rise since July, 1914, being thus brought up to close upon 120 per cent. A rise of over 5 per cent. in retail food prices in Vienna, in April, as compared with the preceding month, is shown by the figures published in the official journal *Warenpreisberichte*, the general level being thus brought up to 121.5 per cent. above that of July, 1914. But both in regard to Berlin and Vienna, the above figures can only be accepted with reserve, since many of the most essential kinds of food are no longer obtainable in the quantity desired.

We have received a copy of a book written by Mr. Thomas Alexander Fyfe, Chairman of the Munitions Tribunal at Glasgow, entitled "Employers and Workmen under the Munitions of War Acts, 1915 and 1916." In his opening statement, the author says that his experience in the Munitions Tribunal has convinced him that a very large proportion of the disputes which arise might be avoided if the employers or their representatives, and also the workmen or their representatives, were more careful to acquaint themselves thoroughly with the details of the novel conditions under which at present industrial work is conducted. He has therefore written the handbook in question, which is explanatory of the duties and responsibilities of both employers and workmen under the said Acts. The Acts and appendices are most carefully referred to in the margin; the 1916 amending clauses to the Act of 1915 are printed in red. Reference to the subject matter is facilitated by a very complete index. The book, which is issued by William Hodge and Co., London and Edinburgh, at the price of 2*s.* 6*d.* net, will be found useful by practically every British citizen.

On Saturday last, Mr. A. D. Steel-Maitland, M.P., Under-Secretary for the Colonies, addressed members of the Workers' Educational Association at the Birmingham University. Dealing with the question of employment after the war, he said that our men would return from the various Fronts looking for reinstatement, and he considered that our first duty was to them. In many cases departments were short-handed; in certain districts they had only 75 per cent. of the men they could use, and many firms, therefore, could take men without displacing anybody. On the other hand, where men and women had been drafted into districts the claims for reinstatement to be made after the war would lead to displacements. There were, however, industries closed down for lack of hands, so it ought to be possible to find considerable employment for the men when they came back. Of course, other measures would have to be taken as well. Everything should be done for the men who were so disabled that they could not return to their former occupations. In this connection came the land question. There was every likelihood of more men being settled on the land, and that would greatly relieve the industrial situation. He did not think that with peace there should be an immediate cessation of Government orders. That might be a rather false economy, causing greater dislocation than it was worth. His feeling was that whether as a Government, a municipality, or as private individual, they should at once schedule the work that could be done, and be ready at the right time to give it out. The problem of female labour was just touched in passing, Mr. Steel-Maitland saying he thought there would have to be equal piece rates for the sexes.

The Conciliation Board for the South Wales Coalfields met last Monday at Cardiff, when they decided to accept the recommendation made by Judge O'Connor on the points which had been in dispute between the owners and the operatives since last July. Judge O'Connor recommended that the Sunday night shift should be regarded as a shift and a fifth, and that a bonus should be paid to ostlers. With regard to surface craftsmen, the Wages Board accepted the terms arranged between the owners and the Enginemen and Stokers' Society.

Following upon our note on page 585 *ante*, Mr. Balfour telegraphed last week to Mr. Macassey, the Chairman of the Commission for the Dilution of Labour on the Clyde and Tyne, as follows:—"Decision of the Clyde District Committee of Ship Constructors' and Shipwrights' Association to adopt an immediate full scheme of dilution is a source of the greatest satisfaction to the Admiralty, who are convinced that this measure is essential to meet the urgent needs of the Navy."

Last week, also, Mr. Balfour held at the Admiralty a meeting with representatives of all the skilled trade unions whose members are engaged in ship construction, the object being to introduce the scheme for the dilution of labour into the Royal Dockyards. The scheme was outlined in an official circular which said that the demands made upon the services of all the available forces of the country, both industrial and military, made it necessary to utilise to the utmost and to the best advantage of the State, the whole of the ability and skill of all the employees engaged in the dockyards. The circular further stated that the scheme of dilution, including female labour, was to be carried out on conditions similar to those arranged by the Ministry of Munitions for Controlled Establishments. The representatives of the trade unions concerned are reported to have intimated that they had no objection to dilution being introduced all round, but they asked for the fullest guarantees being given to the effect that the position of the skilled workmen would not be unduly harmed.

THE WESTINGHOUSE INTEREST.—The Westinghouse Electrical Manufacturing Company reports that the gross sales for 1915–16 were 50,269,240 dols., as compared with 33,671,485 dols. in 1914–15. The expenses of the year were 40,839,344 dols., as compared with 31,109,074 dols., so that the manufacturing profit of the past 12 months was 9,429,896 dols., as compared with 2,562,411 dols. Other income received and charges to be provided for left a final surplus for 1916 of 9,666,789 dols., as compared with a surplus of 2,009,744 dols. worked out for 1915. After providing 2,526,951 dols. for dividends upon the common stock for 1915–16, the company was enabled to carry forward a surplus of 6,859,929 dols. to 1916–17, the corresponding surplus for 1915–16 having been no more than 302,485 dols. The profit for the past year upon the company's common stock was 17.82 per cent., as compared with 6.64 per cent. earned in 1914–15. At the close of March this year the value of the orders on hand was 22,097,995 dols., as compared with 5,414,965 dols. at the close of March, 1915. These totals do not include unfilled orders for war *matériel*, which amount this year to no less than 87,948,734 dols., as compared with 3,486,445 dols. twelve months ago. It is intimated that deliveries in fulfilment of war orders will depend upon the volume of the output required during the duration of the war.

COMBINATION IN THE GERMAN CHEMICAL INDUSTRY.

WITH the exception of the chemical works styled Griesheim-Elektron, which were somewhat late in joining the large new combine of the chemical industries of Germany, all the large concerns have now held their general meetings and sanctioned the new agreement. This agreement includes the Höchster Dye Works, Messrs. Leopold Casella and Co., Kalle and Co., Limited, the Badische Anilin Soda Works, the dye-works of Bayer and Co., the company for the manufacture of aniline dyes at Berlin-Trepton, the chemical works of Weiler-ter Meer, and the chemical works of Griesheim-Elektron. The arrangement provides for a closer co-operation between kindred concerns within the same industry than has ever before been known in Germany. The reasons for the combine are stated to be the uncertainty of the future, the increasing competition on the part of neutral and hostile countries, and a desire to bear jointly the risks connected with foreign affairs. At the same the separate concerns retain their independence and freedom of action, whilst they are to afford each other all possible support and communicate to each other all data acquired in the matter of manufacture, &c. The agreement covers a period of 50 years from January 1, 1916, except in the case of the Griesheim-Elektron concern, for which the agreement will come into operation on January 1, 1917.

The most interesting feature of the affair is that all the profits are to be pooled, the profits being arrived at according to uniform rules, and divided between the different participating concerns according to a fixed percentage. In the case of some of the firms the entire production does not contribute to the profits of the pool, and of others there are some special exceptions, which only later on, according to fixed periods, will accrue to the pool. As regards the Höchster Dye Works, for instance, the special profits on calcium carbide, nitrolim, and certain products derived from these commodities are reserved; for the old combined concerns, the Badische Anilin Co., the Bayer Co., and the Trepton Co., the profits on the new departure at Ludwigshafen in the matter of synthetic ammonia and its products are exempt. The fixing of the participation percentage has, of course, been a difficult task, but a solution was found by the three largest works, the Höchster Dye Works, the Badische Anilin and Soda Co., and the dye works of Bayer and Co., each obtaining 24.82 per cent. of the aggregate pooled profits for the first 10 years, and after the expiration of that time 25.02 per cent. These three works will thus during the first 10 years take 74.46 per cent., and after that period 75.06 per cent. of the aggregate profits of the combine, leaving respectively 25.54 and 24.94 per cent. The Berlin-Trepton Company for aniline dyes has had apportioned to it 8.08 per cent. for the first 10 years and 8.14 per cent. after the lapse of that time. In the old triple combine, Ludwigshafen-Bayer-Trepton, the latter participated with 14 per cent., and the two others with 43 per cent. each. So as to bring the Höchster Co. on the same footing as regards percentage, the capital of this company has been raised to the same amount as that of Ludwigshafen and Bayer by an increase of 4,000,000 marks, issued at a premium of 100 per cent., which price is materially below that ruling in the open market. A further transfer of capital has taken place by the shares of Kalle and Co., in Biebrich, formerly held by the Cassella firm, having passed into the possession of the Höchster concern, which now holds the entire share capital of 6,000,000 marks of the Kalle concern.

The relative position of the works of the combine as regards share of profits is as follows:—

	First 10 Years. Per Cent.	Afterwards Per Cent.
Höchster Dye Works ...	24.82	25.02
Baden Anilin Co.	24.82	25.02
Bayer, Leverkusen	24.82	25.02
Leopold Casella Co. (about)	10.00	
Anilin Co., Trepton	8.08	8.14
Griesheim Works and Weiler-ter Meer Works (about)	7.50	?

With reference to the manner in which the profits available for the last two companies is to be divided, nothing definite has been stated, but it has been surmised that some 6 per cent. will go to the Griesheim-Elektron Co. and 1½ per cent. to the Weiler-ter Meer concern.

It may be mentioned in this connection that the Badische Anilin and Soda Works have just declared a dividend of 20 per cent. for last year, the Bayer works at Leverkusen a dividend likewise of 20 per cent., against 19 per cent. for 1914, and the Weiler-ter Meer works of 12 per cent.

PERSONAL.—We are informed that Mr. F. Dudley Docker, C.B., Chairman of the Metropolitan Carriage, Wagon and Finance Co., Limited, has joined the Committee of the Council for the Organisation of British Engineering Industry.

GERMAN SHIPS IN ITALY.—In order to counteract the false impression created by erroneous statements regarding German ships in Italy, the Italian Chamber of Commerce in London draws the attention of those of their readers who may have overlooked the information given to the Press by the High Commissioner for Italy, Baron E. Mayor des Planches, to the fact that all the German ships which were lying in Italian ports have been seized long ago, and are all in use as merchant ships with the exception of one only, the Luitpold, which, not being serviceable like the others as a cargo boat, is being used as a stationary troopship.

BURNER FOR SIMULTANEOUS GAS AND COAL-FIRING.

CONSTRUCTED BY THE POWER GAS ECONOMY COMPANY, GLASGOW.

Fig. 1.

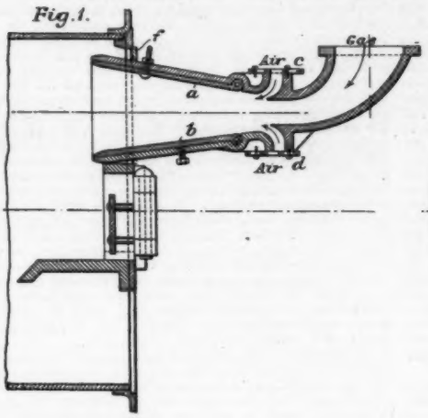


Fig. 2.

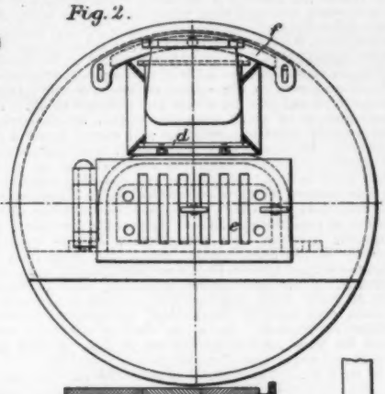


Fig. 3.

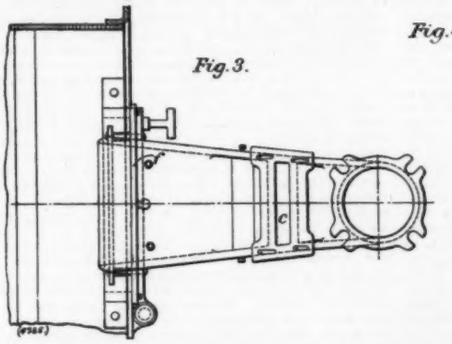
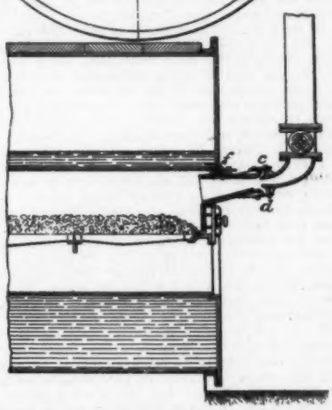


Fig. 4.



THE illustrations above show a burner for the combustion of gas in steam boilers, designed by Mr. T. M. Hunter and constructed by the Power Gas Economy Company, of 50, Wellington-street, Glasgow, a firm of which Mr. T. M. Hunter is the sole partner. The arrangement illustrated is that adopted for the simultaneous use of coal and gas firing in a Lancashire boiler, the fire-grate with dead plate and fire-door being retained. The gas enters at the point shown (Fig. 1) and passes into the mixing-chamber, carrying with it the necessary air for its combustion, this latter entering by the apertures at *e* and *d*, which can be adjusted by regulating-plates (see Figs. 1 and 3). However, as the air current is largely induced by the gas current, there is naturally an automatic adjustment which adapts the supply of air to the varying gas pressures. The mixing-chamber is rectangular in cross-section, and contains two adjustable flaps *a* and *b*, which can be moved nearer together, or further apart, to obtain the best mixture of the air and gas.

This burner may, as shown, be used in connection with coal-firing, and is particularly useful in simultaneous employment with fuel of a poor quality (Fig. 4). Under those circumstances secondary air is admitted by the air inlets *e* in the fire-door. Secondary air is also admitted above and on both sides of the burner by an opening covered by a plate *f*, about 2 in. wide, which extends across the top of the burner and down the two sides, and is hinged on each side. This plate is adjusted in position by a rod and set-screw, as shown in Fig. 4. It is claimed that with this burner an efficiency of 70 per cent. can be obtained with gas firing in Lancashire boilers.

WAR SCHOLARSHIPS.—The Society of Merchant Venturers, in whose Technical College the Faculty of Engineering of the University of Bristol is provided and maintained, have decided to offer 10 scholarships, tenable in the Faculty for three sessions, beginning with the Session 1916–17, to the sons of officers in His Majesty's service who have been killed in the war, and whose mothers or guardians are in needy circumstances.

MURMAN RAILWAY.—This important Russian line is approaching completion and Russia will become accessible to the ocean at all times, as Kola, the Murman port and terminus, is sufficiently free of ice to be kept open for the entry of ships throughout the winter. A large part of the construction of the Murman system was carried out during the hardest months of the severe Russian winter. Great bogs were crossed, although piles and pile-drivers disappeared in them more than once, 30,000 men working through the greater part of the year.

COLONIAL ENGINEERING PROJECTS.

WE give below information on two colonial engineering projects taken from the *Board of Trade Journal*. Further particulars on these can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Newfoundland.—The Imperial Trade Correspondent at St. John's reports that a Bill has recently passed through the Newfoundland Legislature empowering the Governor in Council to raise a loan not exceeding 5,000,000 dols. (about 1,027,700*l.*), of which amount 1,000,000 dols. (about 205,500*l.*), or so much thereof as may be necessary, will be applied to the completion of six branch lines of railway. The Imperial Trade Correspondent also reports the passing of an Act to incorporate the Union Electric Light and Power Company, and for other purposes. The capital of this company will be 100,000 dols. (about 20,550*l.*), and it is authorised to generate and supply electricity for motive power and heating, and to instal an electric lighting system and operate electric tramways in the towns of Trinity, Catalina, Bonavista, &c. The company is also granted the exclusive right to use the waters of several lakes and streams. All plant, machinery, rolling stock, implements, apparatus, tools, utensils and materials necessary for the original construction of the lighting, heating and power and tramway systems, and extensions thereof, will be admitted into Newfoundland free of duty.

TESTING BOILER-SCALE PREVENTATIVES.—When selecting and testing a commercial boiler compound for the new power station of the University of Washington at Seattle, Messrs. H. K. Benson and O. A. Hougen adopted a method which looks useful in its way, but can hardly be accepted as conclusive. The feed-water gave a scale containing about 11 per cent. of organic matter, 30 per cent. of silica, 7.4 per cent. of iron and alumina, 28 per cent. of lime and 5 per cent. of magnesia. Three compounds were submitted: A was a fluid containing water, sodium carbonate, graphite, and a colloidal organic solid; B consisted of solid sodium phosphate; C was a fluid of unknown composition. The tests, described in the *Journal of Industrial and Engineering Chemistry* of May, 1916, show that the three fluids gave coagulated precipitates with the concentrated feed water, and that the precipitates became flocculent on boiling. But the precipitates differed as to the rate at which they settled. This rate was hence studied with the three compounds, in filtered or unfiltered solutions, and also with other preparations, and it resulted that the A precipitates took the longest time to settle, probably owing to their containing colloidal organic compounds. That conclusion may be quite right; but the rate of settling is not alone decisive. If a hard adhesive crust should form finally, instead of a pulverulent precipitate, the rate of settling would matter little, and further experiments would be desirable. The high percentage of organic matter in the feed water might call for a special treatment.

CATALOGUES.

Pressed-Steel Shaft Hangers.—Two pamphlets relating to "Pioneer" pressed-steel hangers for line shafting and countershafts, respectively, have come to hand from the Northern Steel and Hardware Company, Limited, of 9, South Parade, Deansgate, Manchester. Prices and full particulars are given of drop hangers for shafts from 1¼ in. to 4 in. in diameter; post and wall bracket hangers are also listed for shafts up to 3 in. in diameter. It is claimed that these hangers are much lighter and stronger than cast-iron hangers.

Electric-Light Fittings.—A catalogue of electric-light fittings employing their well-known glassware has been issued by Messrs. Holophane, Limited, of 12, Carteret-street, London, S.W. The catalogue illustrates some very pleasing designs of single-light and double-light brackets, standard lamps, suspended bowls for semi-indirect lighting, reflector bowl pendants, sphere pendants, rising and falling pendants, ceiling fittings, electroliers, &c., prices for which are mentioned in every case. The catalogue itself is well printed and illustrated, and is in every way a highly creditable production.

Valves and Cocks.—A handy pocket price-list of valves and cocks manufactured by the Pratt and Cady Company, Inc., has been issued by Messrs. Edward Le Bas and Co., of Dock House, Billiter-street, E.C., who are the agents for these products. The price-list also includes Proctor's discount tables, which give the discount at from 1½ to 98½ per cent. on amounts ranging from 1d. to 100*l.* The tables are arranged so that the exact cost of any article can be obtained by subtracting the percentage discount from 100 and using the table for the remainder. They will thus be particularly useful to engineers and others having to purchase or quote for articles carrying discounts.

Mechanical Lubricators.—We have received from Messrs. Rimington Brothers, of Abbey-street, Carlisle, a catalogue illustrating and describing the Madison–Kipp valveless force-feed lubricator, and illustrating its application to steam engines, gas and oil engines, agricultural machinery, machine tools, &c. In these lubricators each delivery pump is provided with separate forcing and measuring plungers, the former being driven by an eccentric placed with its plane at an angle with the driving shaft, so that the plunger has a combined reciprocating and semi-rotary motion. By means of gears a similar motion is imparted to the measuring plunger, which is hollow and has suction, delivery and overflow ports. This plunger works in a sleeve which is provided with similar ports and can be adjusted longitudinally by means of a screw to vary the relative positions of the ports in the sleeve and plunger, and thereby regulate the quantity of oil delivered at each stroke. The barrels are of close-grained grey iron, and the plungers are of hardened steel. Both are finished by grinding to give an accurate fit without packing of any kind. The oil reservoir is of sheet steel, and it may, if necessary, be divided into two or more compartments to hold different grades of oil. Simplicity and reliability are the most important claims for these lubricators, but several other special features are dealt with in the catalogue.

Phase-Shifting Transformers.—Messrs. H. Tinsley and Co., of Eldon Park Works, South Norwood, S.E., have issued a booklet illustrating and describing Dr. Drysdale's phase-shifting transformers which they manufacture. With these transformers, which are used for testing supply meters and wattmeters, a current leading or lagging at any angle with the voltage can be obtained with either single-phase or polyphase currents. The transformer is constructed with a stator and rotor resembling an induction motor with a vertical axis, and the current from a polyphase supply, or a single-phase supply with a phase-splitting device, is made to produce a rotating field in the transformer. The electromotive force induced in the rotor in this way is constant, but by turning the rotor by means of a worm-gear the power factor can be varied at will. Both stator and rotor windings have a sinusoidal distribution, so that, if the former is supplied from a source with a good wave form, the secondary potential difference will always be sinusoidal at all loads and power factors. The rotor is provided with a pointer, which moves over a scale when the rotor is turned and enables the angle of lag, and the value of $\cos \phi$, to be seen at a glance. The booklet gives full particulars of the performance of the transformers, and explains the procedure necessary for carrying out tests with them. It also states prices for transformers with capacities of 250 and 750 volt-amperes respectively, and for accessories such as phase-splitting condensers and resistances.

FRENCH IMPORTS AND EXPORTS OF METALS AND MACHINERY.—The United States Consul-General in Paris gives the following figures in metric tons for the French imports and exports of metals and machinery, which are reproduced in the *Iron Age*:—

Imports.	1914.	1915.
Automobiles, commercial (number)	454	20,395
Automobiles, passenger (number)	1,927	1,443
Coal	15,430,358	19,067,743
Copper, raw	78,522	111,400
Iron and steel	109,550	927,358
Machinery	149,560	100,976
Tools and metal work	46,810	164,730
Iron ore	1,044,160	397,348
Tin	7,216	9,003
Exports.		
Iron Ore	4,828,592	94,864
Machinery	57,738	15,475
Tools and metal goods	100,977	28,230
Pig-iron, iron and steel	419,142	152,117

BOILER EXPLOSION AT SPALDING.

A FORMAL investigation has been conducted by the Board of Trade under the Boiler Explosions Act, 1882, at the Sessions House, Spalding, with regard to the cause and circumstances of an explosion which occurred on October 8 last, at the works of Mr. Fred Armstrong, hay and straw dealer, Spalding. The Commissioners were Mr. A. A. Hudson, K.C. (presiding), and Mr. I. McLaren. Mr. G. E. Vaux appeared on behalf of the Board of Trade, and Mr. C. E. Dyer, barrister, London, for Mr. Armstrong.

In opening the proceedings, Mr. Vaux stated that Mr. Armstrong was a hay, straw and corn merchant, and had two vessels in use at his works for steaming chaff in preparation for cattle-feeding purposes. They were cylindrical in form, and were suspended from a wooden framework, with the lower ends about 5 ft. from the ground. The right-hand cylinder, which was the one which exploded, was designed and erected in 1902, under the supervision of the late Mr. Hall, engineer, of Newark-on-Trent, and was made by Messrs. Renshaw and Co., of Stoke-on-Trent. It was about 14 ft. in height by 7 ft. in diameter, the shell being formed of three rings of plating of mild steel, the lower ring being $\frac{1}{2}$ in. thick, the middle $\frac{7}{16}$ in., and the third $\frac{3}{8}$ in. Before leaving the makers' works the cylinder was tested by hydraulic pressure to 110 lb. per square inch, and at first was worked at a pressure of 100 lb. per square inch, but in 1905 it was found that for the purpose of steaming the chaff the desired result could be obtained at a lower pressure, and it was therefore reduced to 75 lb., and the cylinder was worked for seven years at that pressure, after which it was further reduced in 1912 to 70 lb. There were two boilers on the works which supplied the steam, the safety-valve of one of them blowing off at 150 lb. and the other at 170 lb.

After describing the methods adopted for filling and emptying the cylinders, Mr. Vaux stated that it was found in May, 1912, that the bottom end of the right-hand cylinder required renewal owing to internal wasting. An order was therefore given to Messrs. Renshaw, and a new steel end-plate, $\frac{1}{2}$ in. thick, was supplied. In 1913 Mr. A. Hunt, who was by trade a miller, was appointed as foreman, and from that time the supervision of the safe working of the plant appeared to have been left in his hands, no engineer being employed at the works. Mr. Hunt made an inspection of the cylinders by sounding them with a hammer from time to time, but did not appear to have made any written report to Mr. Armstrong. No other person ever examined the cylinders and they were not insured. Early in 1915 the end plate of the left-hand cylinder started to leak, and it was found that the leakage proceeded from a corroded place in the bottom plate. A new end was supplied, and as these repairs occupied some considerable time, the right-hand cylinder was kept at work. About September last Mr. Hunt made an inspection of this cylinder, and then noticed that the bottom end-plate had become thinned at one side; he did not, however, seem to have considered that there was any danger, but reported the matter to Mr. Armstrong that he might know that thinning had started. On October 8, shortly after 7 a.m., the right-hand cylinder was filled with chaff and the steam was turned on. At about 7.30, the steam having percolated through the chaff, it was shut off, and more chaff was then put in and the steam turned on again. About 7.40 a.m. the gauge on the cylinder showed 70 lb. pressure, and the one on the boiler which was supplying the cylinder with steam showed 90 lb. At 7.55 the attendant noticed that the gauge on the cylinder still showed 70 lb., and it was at that time that the explosion occurred.

The explosion was of a very violent character: the bottom plate of the right-hand cylinder was fractured and was blown through a wooden partition into the adjoining engine-house. Both cylinders were thrown over, one of them falling upon a boilermaker who was working at the left-hand cylinder, and crushing him to death. Another boilermaker was very severely scalded, and two labourers were more or less injured.

Mr. Vaux stated that a feature of the case seemed to be the disparity in the life of the first two bottom ends and the other two bottom ends. Apparently they were made of the same kind of steel and of the same thickness. The first two ends lasted from 1902 until 1912—10 years—before they required renewal. In the case of the last two ends, however, one lasted about three years, and the other not quite three years, as against 10 years for the original plates.

Mr. Vaux then proceeded to call witnesses, some of whom were examined at considerable length.

Mr. Armstrong, owner of the works, in the course of his evidence, said he did not remember any particular report having been made to him as to the condition of the cylinders. It was a duty of his foreman to make such reports if there was anything wrong.

Another witness was Philip Booth, who said that he had been engine attendant for 11 years. He had had no experience of boilers before starting with Mr. Armstrong, nor had he any mechanical knowledge.

Mr. Thomas Miller, engineer-surveyor to the Board of Trade, presented a report on his examination of the exploded cylinder, and laid before the Court numerous plans and drawings, as well as photographs of the wrecked premises, cylinder ends, &c. The explosion was due to corrosion and wasting of the bottom plate, which at one part was only $\frac{1}{8}$ in. thick.

After further evidence had been taken, which need not be specially referred to, Mr. Dyer addressed the Commissioners on behalf of Mr. Armstrong, and pointed out that his client had already suffered a loss estimated at about 2000*l.*, and urged that he should not be called upon to bear any part of the expenses of that inquiry.

The presiding Commissioner, Mr. Hudson, then delivered judgment at great length. He said this was an inquiry as to the explosion of a cylinder used for steaming chaff, and known by some persons as a "fodder digestor." He traced the history of the design and erection of the two vessels, and said that, from calculations which had been submitted to the Commissioners by the engineer-surveyor to the Board of Trade, it was evident that they were originally fit for a working pressure of 70 lb. No question, however, need arise as to the pressure at which steam was used in the cylinders, because the cylinder which exploded was not fit for any pressure at all. The chief matter to which attention should be directed in that inquiry was the supervision and management of the cylinder. Mr. Armstrong, the owner, was a keen man of business, judging from the letters which he wrote from time to time, and nothing escaped his attention as to the matters which were referred to in those letters. He had told the Court that he knew nothing about boilers or engines, and left all that to his foreman. He retained, however, the management of the business entirely in his own hands. About the year 1905 he engaged a man named Booth to take charge, under the foreman, of the two boilers generating steam. Booth was 20 years of age and had not had any experience of boilers, and had no mechanical knowledge of either boilers or engines; he quite frankly admitted that what he knew he had picked up in looking after the boilers and engines on these works.

In 1912 Mr. Hinkins reported that the bottom plates of the two cylinders required renewal; they were both about in the same condition, being badly wasted and pitted, and Hinkins considered that the condition of these plates was about the same as the one which subsequently exploded. Mr. Armstrong, however, decided to replace the plate on one cylinder only, and the other cylinder was kept working apparently to its full capacity. During the same year the other cylinder was laid off and repaired. From that time to July, 1913, no foreman was employed, and there was no one left on the works to look after the cylinders except a labourer. Booth, however, turned the steam on and off when the man told him that the cylinders were ready. By this time the cylinders had been demonstrated to be liable to serious wasting and grooving, yet there was no skilled person left in charge of them. In July, 1913, a man named Hunt, who was a miller and served his apprenticeship to that trade, became foreman. In July, 1914, he noticed that the bottom plates in both cylinders were wasting, and he called Mr. Armstrong's attention to the matter. Mr. Armstrong said he must be mistaken, because the cylinder bottoms were nearly new. There had been some discussion at that inquiry as to whether Mr. Armstrong did say this, but it was a perfectly natural remark for him to make, having regard to the short time they had been in use. Hunt had very little technical knowledge of boilers, but he had sufficient commonsense to know that the bottom plates were wasting. The Commissioners, however, doubted whether he really made the inspection in the way he told them he did, and were quite satisfied that he could not possibly know how to make a proper inspection of a boiler; indeed, he could not be expected to know, with his qualifications. One piece of evidence he gave threw some light on the cause of the wasting in these cylinders: he merely raked them out, with the result that, whatever extraneous matter which existed, and which was affecting the plates, was allowed to remain from one year's end to another.

In August, 1915, Hunt reported that the bottom plate of the left-hand cylinder was wasting, and he asked Mr. Armstrong to look at it, and Mr. Armstrong saw a leak through the plate, the defect being limited to about 3 in. to 4 in. Hunt also examined the bottom plate of the right-hand cylinder, and told the Commissioners that there was no great difference between the condition of these two bottom plates since he examined them in 1914; but in the opinion of the Court he could not have had sufficient knowledge to distinguish the difference. With regard to the left-hand cylinder, which he had had an opportunity of examining after it had been taken out, Hunt had told the Court that he thought the thickness of the metal at the grooved part was reduced to about $\frac{1}{8}$ in., though he had no gauge wherewith to measure it. Mr. Renshaw, boilermaker, gave an estimate for replacing the defective plate in the left-hand cylinder, and it was while he was engaged on these repairs that the explosion of the right-hand cylinder occurred. He saw that the plate, when taken out, was rather badly wasted and grooved; but notwithstanding this condition of the bottom plate of the left-hand cylinder, which must have been known in August, 1915, to Mr. Armstrong, no proper inspection was made of the cylinder, while it was kept in use, although this could easily have been done. The cylinders, with their large bottom doors, admitted of inspection with the greatest ease; in fact, anyone standing on a chair could inspect the bottom plates fairly well; and if a closer inspection was desired, a person could step up into the cylinder and walk round it without the slightest impediment. With the experience Mr. Armstrong had had in the case of prior defects and repairs, the inference, to a person of ordinary intelligence, was that the plates would again be subject to the same defects, and there was, further, the remarkable circumstance, quite sufficient to put anyone on the alert, that the 1912 plates had only lasted three years, whereas the first plates had lasted 10 years. It was not to be wondered at that accidents happened when so little thought or care was devoted to steam plant which was capable of such serious results. Mr. Armstrong appeared to have had some anxious moments as to the condition of the right-hand cylinder, which was kept in work, for in a letter dated August 26 he said: "I am very anxious, for reasons previously explained, to have the work done practically at once."

The plate for the left-hand cylinder having been completed, the boilermakers started to work fitting it on October 5, and proceeded up to and including October 8, when the explosion of the other cylinder occurred. After the explosion it was found that the bottom plate had fractured in the position in which the circumferential grooving had taken place in the bottom plate of the left-hand cylinder, then under repair, and in precisely the same position, or within an inch or two of the circumferential grooving which was found in the two bottom plates replaced in 1912. The metal was reduced on the side opposite to the steam-pipe to $\frac{1}{8}$ in., and there was considerable grooving radiating from the manhole-door to the outside of the cylinder. This grooving was so pronounced that anyone must have known that some serious change had taken place in the metal. The cause of this rapid grooving and wasting was probably due—and the Commissioners thought they might say certainly due—to some extraneous matter. It had been suggested as a cause that the chaff, when steamed, threw off some acid. The Board of Trade had not had any chemical analysis made of the moisture deposited in the cylinders, so that nothing very definite could be stated as to the precise nature of the extraneous matter which caused this rapid wasting of the plates, but there appeared to be little doubt that the process of steaming chaff did give off some foreign matter which attacked the surfaces of the metal with which they were constructed.

The Commissioner then went on to deal with the responsibility of the parties to the inquiry. As to Mr. Hunt, he was only a miller by trade, and did not appear to have in any way pretended that he had any knowledge of boilers, which he did not really possess. His duty was to report to Mr. Armstrong if he saw anything wrong, and he certainly did report when matters were serious. The Court, therefore, did not find that he was responsible for the explosion. With regard to Mr. Armstrong, he complied, as he was compelled to do, with the Factory Act, by obtaining a certificate from a competent person periodically as to the condition of the boilers generating steam. But as regards these cylinders, from the first day of their being set up until the day of the explosion, he never employed any competent person to inspect them, or any person to advise him as to the condition of the plates which gave out from time to time. He managed his business throughout himself, and it necessarily followed, from his requiring reports to be made to him, that with him rested the final decision as to what should or should not be done, when he obtained the reports from those whom he had employed. But though employing persons with little or no knowledge of boilers, he professed entire ignorance himself of either boilers or engines. He had told the Court that he did not know the different types of boilers; he did not remember what the safety-valves blew off at, and he had said that he took no part in the working of the steam plant. Further, he had told the Court that the safe working of the plant was left entirely to these respective foremen, though he knew perfectly well that they were men who were not qualified to undertake or be left in charge of the safe working of a steam plant. He had also said that he could not remember what instructions he had given to Hunt when he entered his service. All he had said was that Booth, who was the engine attendant, would let him know about the work.

This was a most extraordinary position to place a foreman in—he was not told what to do, given no definite instructions, and he was to find out from his subordinates what his duties were. If Mr. Armstrong was as ignorant as he professed to be, so much the greater was the duty cast upon him to employ men capable of performing the duties entrusted to them. He had told the Court that these foremen had a duty to report to him, and it was quite clear that they had reported; but from the moment they did so a duty was cast upon Mr. Armstrong to make the fullest inquiries as to such reports; and if he was so ignorant and could not possibly understand, he should have obtained professional and skilled advice, so as to inform himself how he was to act. But instead of doing this, he took upon himself to decide what was wanted, and when it was wanted, and put his business as a corn, hay and potato merchant before everything else. From reports received in 1912 he knew that both cylinder ends required renewal, but he deferred the renewal of the second for 12 months. In 1915, when the bottom plate gave out, he did not obtain any skilled advice as to the condition of the plate of the other cylinder, though he must have been told or expected that it was in the condition of the left-hand cylinder bottom plate, because it had been in longer than the other. Further, he kept the right-hand cylinder at work while the left-hand one was undergoing repairs, and that led to the explosion, with its serious results. The responsibility therefore rested upon Mr. Armstrong.

In concluding his lengthy summing up and judgment, the presiding Commissioner said that, in a word, the cause of the explosion was that the cylinder was subjected to a greater pressure of steam than it was capable of withstanding, due to the weakened condition of the bottom plate by internal wasting and grooving. The Court therefore had decided that Mr. Armstrong was to blame for the explosion.

At the invitation of the presiding Commissioner, Mr. Dyer again addressed the Court on behalf of Mr. Armstrong, who, he said, had already been visited very heavily as a result of the explosion; he was uninsured, he had paid compensation in respect of the poor man who had unfortunately lost his life, and his total loss, as had already been stated, was about 2000*l.* This being so, Mr. Dyer submitted that his client had already been sufficiently mulcted in damages, and pleaded that he should not be further penalised by having to pay costs.

The presiding Commissioner ordered that Mr. Armstrong should pay to the Board of Trade the sum of 100*l.* towards the costs of the inquiry. Mr. Vaux estimated that the total costs would be about 150*l.*

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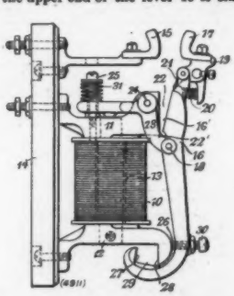
ELECTRICAL APPARATUS.

4911/15. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*). **Electro-Magnetic Switches.** [5 *Figs.*] March 30, 1915.—The invention relates to electro-magnetic switches for the control of electric circuits, and more particularly to the class of switch now known as "lock-out switches" used particularly for automatically starting and controlling electric motors. An electro-magnetic lock-out switch, according to this invention, has its armature mounted on a movable pivot controlled by a spring, and its magnetic system so arranged that when the switch is excited the armature is acted upon by opposing magnetic forces, and is moved on to another fulcrum in a direction to close the switch, the final closure occurring at a predetermined current value when the spring force exceeds the difference between the opposing magnetic forces. 10 represents an energising winding for magnetising the magnetic structure composed of an upper pole-piece 11 and a lower pole-piece 12 connected by a core 13. These parts, together with the winding 10 mounted upon the core, form an electro-magnet which is secured to an insulating base 14. A fixed contact 15 is also secured to the insulating base adjacent the magnet, so as to co-operate with the moving contact. An armature lever 16 is pivoted at 18, and is provided at its upper end with a contact 17 co-operating with the stationary contact 15. These contacts 15 and 17 are shaped so as to wipe or roll upon each other in a manner now well understood in the art, and to this end the contact 17 is mounted upon a pivoted bracket 19 which is spring-pressed by means of a spring 20 to move the contact 17 toward the fixed contact, there being a stop 21 for limiting the movement. The armature lever 16 is elongated in shape so as to co-operate with both the upper pole-piece 11 and the lower pole-piece 12. The upper pole-piece 11 is enlarged so as to afford a wide face, and the upper end of the lever 16 is similarly formed



so as to be held by the pole-piece across the gap 22, which may be called the "closing gap." The armature 16 is pivoted to the bell-crank lever 23, preferably of brass or other non-magnetic material, which lever is pivoted at 24 to the magnetic frame. The inner end of the lever 23 is pressed downward by a spring 31 interposed between the end of the lever and the head of a screw 25 which passes through the spring and is screwed into the magnetic frame. The lower end of the armature 16 co-operates with the pole-piece 12, which is also enlarged to give an effective pull across the gap 26, which may be called "the holding-out gap." This armature lever is shown curved at its lower end and terminating in a flat surface 27 which co-operates with a flat surface 28 on the pole-piece 12. These two faces 27 and 28 are in contact when the switch is closed, so as to form a closed magnetic circuit. There is also some attraction during the closing movement between these pole-faces 27 and 28 across the gap 29, which constitutes an auxiliary closing gap. The pivotal point of the switch armature 16 is adjacent to the upper end, and the spring normally forces the bell-crank lever to the position shown in Fig. 1, in which position the upper end of the armature is forced outward from the pole-piece to its maximum distance. The switch armature and the attached parts are so located, and the weight is so distributed around the pivot that the lower end of the armature normally bears against the pole-piece 12, there being an adjusting-screw 30 for adjusting the gap between the lower end of the armature and the pole-piece. The face 16^1 of the upper end of the lever in the normal position of the latter is at such an angle with the face of the pole-piece 11 that when the pivot 18 is moved inward by the attraction across the gap 22 the lower edge of the face 16^1 on the armature engages the pole-piece 11, a fulcrum being formed at 22^1. The armature 16 now turns on this fulcrum, when it is moved to its closed position by the pressure of the spring 31 supplemented by the pull across the gap 22 and the slight pull across the gap 29. (*Sealed.*)

7554/15. A. H. Railing, C. C. Garrard, and A. F. Searle, London. Electric Switches and Plugs. [3 *Figs.*] May 20, 1915.—This invention relates to improvements in switching and connecting apparatus of the type employing means for preventing the insertion of the plug if the switch has been previously closed, or after the plug is inserted and the switch then closed, locking the plug to the switch to prevent its withdrawal until the switch is again opened. The invention comprises a spring-controlled sliding locking-bar operating inside the apparatus before a guide-hole in the casing and mounted on the casing independently of the switch-handle, the bar being provided with a hole capable of coinciding with the guide-hole, and means associated with the axle of the switch to move the locking-bar. It also comprises a guide-pin on the plug member provided with an annular or suitable groove. In carrying out the invention, a locking-bar or piece A is provided, which is arranged to slide before a hole B in the casing C, being retained in position on the casing by the shouldered studs D passing through slots in the bar; it is provided with a hole E, and is moved against the force of the spring-plunger F by the abutment G, which is associated with the handle H of the switch, and swings therewith. The plug member is furnished with a guide-pin J, which is formed with an annular groove J^1 or other suitable recess. The open position of the switch is indicated by Fig. 2, where, as will be seen, the abutment G acting through the adjustment-screw K, has forced the locking-bar A against the force of the spring-plunger F into a position where the hole E of the bar coincides with the hole B in the casing C. The guide-pin J can consequently be now inserted through the guide-hole B, and

Fig. 1

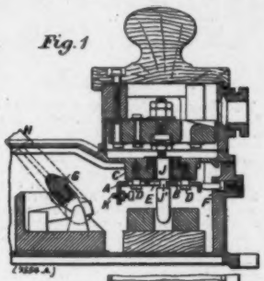
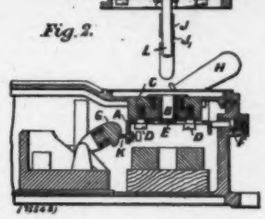


Fig. 2.



at the same time the plug-pins, one of which is shown at L, can be connected with the inside sockets. When the plug is inserted and the switch then closed, the abutment G, moving with the axle of the handle H, allows the locking-bar A to move forward, urged by the spring-plunger F, and the back edge of the hole E in the bar entering into the groove J^1 of the guide-pin J (see Fig. 1) effectually locks the plug member to the switch against withdrawal until the switch is again opened. Thus the plug cannot be used to open the circuit. If the plug is out and the switch closed, the position of the bar A is such that it obstructs the passage of the guide-pin J, and so prevents the insertion of the plug whilst the sockets are "live." Thus the plug cannot be used to close the circuit. (*Sealed.*)

2786/15. J. Torner, Barcelona, Spain. Transformers. [3 *Figs.*] February 21, 1914.—This invention relates to improvements in electric transformers of the kind wherein the primary and secondary windings are mounted on a closed core and a bridge permeable to the lines of force is arranged between the said windings and mounted so that it can be moved into or withdrawn from the magnetic field. In some of such transformers, the closed core is provided with an inner cross-bar on which the primary and secondary windings are mounted, and the bridge is fork-shaped to allow passage thereof past the cross-bar, and in certain constructions the bridge has a swinging movement and always remains in the magnetic field. According to this invention, the bridge is influenced by a spring or by gravity, so that it is normally held outside the core, but is drawn into the space in the core when the magnetic force reaches a certain value. The primary winding 1 and the secondary winding 2 are wound on

Fig. 1.

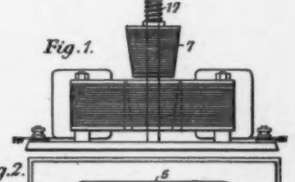
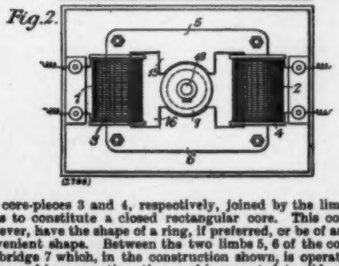


Fig. 2.



the core-pieces 3 and 4, respectively, joined by the limbs 5, 6, so as to constitute a closed rectangular core. This core may, however, have the shape of a ring, if preferred, or be of any other convenient shape. Between the two limbs 5, 6 of the core there is a bridge 7 which, in the construction shown, is operated by a spring and by magnetic action, and is mounted to slide on a rod 18, and is held by a spring 17, which tends to hold it outside the core, as shown in Fig. 1. The bridge shown has the shape of a truncated cone, and the limbs 5 and 6 have inward projections 15 and 16 conforming in shape to the periphery of the bridge. The bridge may, however, be of any other convenient shape. The induction due to the primary winding acts on the secondary winding 2, as in an ordinary static transformer, until a certain limit is reached at which the magnetic pull overpowers the spring 17, so that the bridge is attracted, and gradually enters the space between the limbs, causing deflection of lines of force, and consequently reduction of the induction in the secondary winding. (*Sealed.*)

GUNS AND EXPLOSIVES.

2112/15. E. Edser, London. Apparatus to Facilitate Training in Marksmanship. [3 *Figs.*] February 10, 1915.—This invention provides a simple and efficient device which will facilitate preliminary training in marksmanship with the rifle or other small-arms without the consumption of ammunition. The object of the present invention is to provide a device by which the instructor may check the accuracy of the aim and also any movement of the rifle during sighting and pull-off. A device is therefore provided upon the rifle of the type comprising a glow-lamp and means to focus an image of the filament upon the target, and, according to the invention, the image is focussed upon a spot other than that aimed at, so that it does not lie in line with the sights, and thus does not interfere with their normal use. In other words, the person using the rifle is not guided in his aim by the light, but by the rifle-sights only, as in actual practical use of the rifle. Fig. 1 shows the apparatus in section attached to the service rifle. The metal tube A is attached to the rifle in a manner essentially similar to that used with the bayonet; the spring catch which forms part of the bayonet attachment may be omitted, however. The small electric glow-lamp D is held in position at the rear end of the tube A; the lamp may be similar to that used in connection with an "electric torch." The screw-thread of the lamp (which forms one terminal of the lamp) fits into a screwed metal socket which is connected electrically with the tube A, while the central terminal of the lamp is connected electrically with a binding-screw, which is insulated from the tube A. The lens B, which is preferably plano-convex, is fixed in a tube C, which slides in the tube A; thus the position of the lens can be adjusted so that the image of the glowing filament of the lamp is focussed on the target or on a screen placed in a convenient position. The focal length of the

Fig. 1.

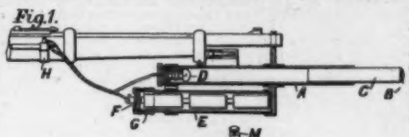


Fig. 2.

lens may be about 12 in.; in this case the distance between the lens and the lamp should be capable of adjustment between 12 in. and about 18 in. The tube E, which carries a battery of three dry cells, is attached to the tube A by metal bands. The dry cells, similar to those used for one type of "electric torch," are insulated from the walls of the tube E by means of a cardboard tube not shown in Fig. 1. The zinc terminal of the battery is pressed against a spring at the right-hand end of the tube E, thus making contact with that tube; the other terminal of the battery is pressed against a contact-piece, which is electrically connected with a binder-screw attached to a disc of ebonite F, which is held in position by the screw-collar G, so that this terminal of the battery is insulated from the tube E. The electric circuit of the battery will be completed through the lamp when this insulated terminal is connected electrically through the insulated terminal of the lamp; this is effected by a switch held in position on the stock of the rifle by a spring H. This switch is shown in perspective on a large scale in Fig. 2. The spring H is U-shaped, and fits on the stock of the rifle just behind the rear sight, in which position the switch can be closed by the fingers of the left hand while aim is being taken. A block of insulating material K, such as ebonite or vulcanised fibre, is fastened to one end of the U-shaped spring. Two metal tongues N and P are attached to this block, so that they are insulated from each other. The tongue N is connected to the binding-screw M, while the tongue P is connected to the binding-screw L. An insulated wire connects the binding-screw L of the insulated lamp terminal, another insulated wire connects the binding-screw M to the insulated terminal of the battery. Thus when the tongues N and P are pressed together by the fingers of the left hand the electric circuit of the battery is completed through the lamp and the wall of the metal tubes. (*Sealed.*)

HYDRAULIC MACHINERY.

2415/15. Babcock and Wilcox, Limited, and H. B. Reynolds, London. Hydraulic Presses. [5 *Figs.*] February 15, 1915.—This invention relates to improvements in

Fig. 1.

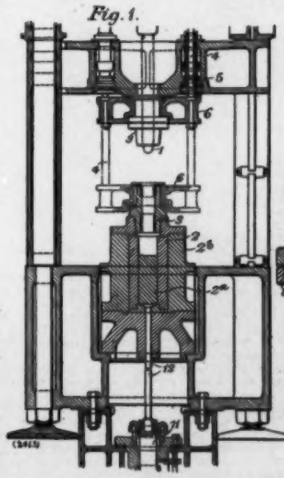
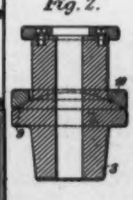


Fig. 2.

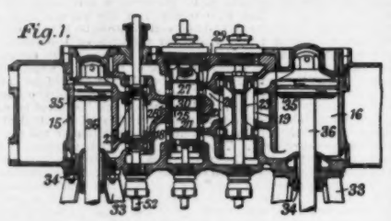


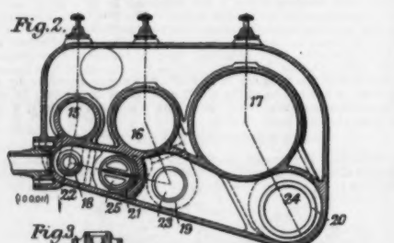
hydraulic presses for forging hollow articles, particularly projectiles and the like, and has for its object to provide for more perfect guidance of the mandrel coaxially with the die than here-

before accomplished whereby projectiles or the like of uniform thickness may be produced. Hitherto it has been proposed to provide an hydraulic press with an axially movable bush engaging the die and sleeving the mandrel so as to ensure that the mandrel will be maintained coaxial with the die. The present invention consists in the provision of an hydraulic ram or rams for controlling the movements of the bush and maintaining the bush in operative relationship with the die, such ram or rams being independent of the mandrel-operating ram. The improved hydraulic press comprises a main ram terminating in a mandrel 1 constrained to move axially into a hollow die 2 containing the billet 2a and carried by a die-holder 2b. The end of the mandrel 1 is accommodated in, and is slidable relatively to, a bush 3, which is constrained to perform axial movements into and out of engagement with a counterpart pocket formed in the die or in a member fitted thereto. For imparting the requisite movements to the bush 3 there are provided supplementary hydraulic rams, of which the plungers 4 are guided in bushes 5 and secured to a member 6 in which the bush 3 is housed. The bush 3 may be of frusto-conical or cylindrical form. It will be readily understood that as the bush 3 is constrained to enter a pocket located immediately adjacent to the die 2, the mandrel will in operation always occupy a position coaxial with the die 2. A ram 11 and co-operating mandrels 12 are provided for ejecting the billets. To compensate for any tilting movement of the member 6 caused by the rams or plungers 4 not moving in unison, the bush 3 is formed at 9 (Fig. 2) with a spherical surface, presenting in conjunction with a correspondingly formed washer 10 a universal joint. It follows that any tilting movement of the member 6 is not communicated to the bush 3. (*Sealed.*)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

100,011. R. L. D'Espujols, Joinville le Pont, France. Multiple-Expansion Steam-Engines. [7 *Figs.*] January 30, 1914.—This invention relates to steam-engines for automobiles and for other purposes, and has more especially for its object to provide improved means whereby a multi-cylinder engine may be operated either as a compound engine or as a triple-expansion engine. It has also for its object to provide improved means for operating the distributing-valves of the several cylinders of the engine. According to the invention, the engine comprises three cylinders, one a high-pressure cylinder, another a medium-pressure cylinder, and the third a low-pressure cylinder, and is provided with a suitable slide-valve, serving as an intercepting slide-valve, whereby these cylinders can be caused to form a group acting by triple expansion, or the first two may be caused to act with live steam, and the steam that has acted in the said cylinders may be exhausted into the low-pressure cylinder, in which case the motor runs as a compound engine. This arrangement of the engine renders it possible to dispense with all the intermediate members, such as a change-speed gear, between the engine and the drive for the wheels, and to do so without having recourse to excessive pressures. The engine comprises a block of cylinders cast in one piece, and comprising the high-pressure cylinder 15, the medium-pressure cylinder 16, and the low-pressure cylinder 17, and also the three ordinary distributing chests 18, 19, and 20 of each of these cylinders, and the chest 21 of the combined valve is hereinafter described. The three cylinders 15, 16,

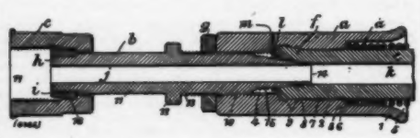




and 17 are constructed so that the sum of their diagrams approximates as closely as possible to the theoretical diagram of total expansion as is required by the constructional conditions of every multiple-expansion engine. Each of the cylinders 15, 16, and 17 respectively is provided with a cylindrical slide-valve (or a valve of any other form, such as, for instance, even poppet-valve distributors) 22, 23, 24, which operates in the chests 18, 19, 20. Between the distributors or valves 22 and 23 of the high-pressure cylinder 15 and the medium-pressure cylinder 16 the intercepting-valve 25 is interposed; this is independent of the rotation of the engine, and serves the following purpose:—Up to a 7 per cent. gradient it permits of operating with the three cylinders 15, 16, and 17 in triple expansion. Beyond this limit the triple expansion is transformed into double expansion, the high-pressure cylinder and the medium-pressure cylinder 16 acting with the live steam of the generator, and both exhausting into the low-pressure cylinder 17. In this latter method of operation, the intercepting valve 25 places in communication the inlet for the initial steam 28, 29 with the admission ports of the medium-pressure cylinder 16 by the intermediary chamber 30 and of the central lenticular conduit 31 formed in the intercepting-valve. It also places in communication the exhaust-ports of the high-pressure cylinder 15 with the exhaust-pipe 26 of the medium-pressure cylinder 16, and it effects this communication by means of the chambers 27. The common exhaust of the cylinders 15 and 16 to the low-pressure cylinder 17 is effected by the communication of the conduit 26 with the admission of the low-pressure cylinder 17. In *Fig.* 1 the intercepting-valve 25 is shown in the position for operation by double expansion. The cylinders 15, 16, and 17 are connected with the crank-case 32 by three stay slideways 33 provided with the stuffing-box glands 34, fitted so as to secure perfect centring of each cylinder respectively to the line of the shaft. The pistons 35 are secured to the rods 36 by known means. The valves 22, 23, and 24 of the cylinders 15, 16 and 17 are actuated by three eccentric cams, each of which operates a cage, guided at its lower extremity by a rod, and at the upper part by another rod connected by an arm with the rod 52 of the corresponding valve. This method of operating the valves entirely eliminates any influence due to the obliquity of the rods. The shaft carrying the cams can assume, relatively to the crank-shaft, positions which are either in advance or in retard, corresponding to different periods of admission and of reversed running. (*Sealed.*)

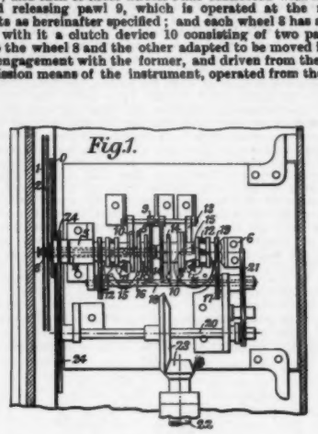
MISCELLANEOUS.

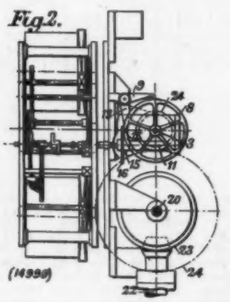
4765/15. The Electric Hose and Rubber Company, Limited, Westminster, and R. H. Carr, Leeds. Hose-Couplings. [4 *Figs.*] March 27, 1915.—This invention relates to improvements in high-pressure hydraulic couplings which are particularly applicable for armoured flexible hose-pipes. The object of the present invention is to provide a coupling which can be readily attached to the end of a hose-pipe, and which will stand a very high hydraulic pressure, and in which the end of the hose-pipe is arranged to be readily expanded within the outer coupling-box. According to this invention, the coupling consists essentially of three portions—namely, an outer coupling-box, an inner coupling-plug, and a union connection at the outer end of the said plug—which are arranged to be fitted together, whereby the end of the armoured hose-pipe is made to fit against the shoulder of the parallel portion of one of the internal diameters of the coupling-box, and to be expanded therein by the coupling-plug. The coupling consists essentially of an outer coupling-box *a*, an inner coupling-plug *b*, and a union connection *c*. The outer coupling-box *a* is made of any suitable size and length, and is bored or formed with a series of internal diameters; four are shown in the drawings, and marked 1, 2, 3, 4. The larger diameter is bored for a portion of its length parallel, and is then flared outwards at 5 to, say, a bell shape, to protect the armouring *d* of the hose-pipe *e*, which is of any ordinary construction, and to prevent any sharp bending thereof. The inner end of the armouring of the hose-pipe *e* is made to abut against the shoulder 6 of the parallel portion of the internal diameter 1. The shoulder is formed by the second and reduced diameter 2. The second and smaller diameter is made parallel and provided with a screw-thread 7, say, for example, a left-hand screw-thread, which is made to engage with the outer periphery of the unarmoured end *f* of the hose-pipe *e*. The second diameter may also be countersunk at 8 or tapered from the shoulder 6 in order to provide a lead for the hose-pipe to readily enter the second and screwed diameter 2. The third internal diameter—marked 3 in the drawing—is practically a continuation of the second, and it is bored conical and made plain—that is, there is no screw-thread formed therein, but two circumferential V-shaped grooves 9 may be provided in the tapering internal diameter 3 for assisting in retaining the unarmoured end of the hose-pipe in position. The larger part of the cone or tapering portion of the internal diameter 3 is arranged to be furthest from the hereinbefore-mentioned bell-shaped end of the outer coupling-box *a*. The next—the smallest—diameter, marked 4, is bored



from the end of the outer coupling-box *a* opposite to the bell-shaped end 5, and it is in connection with the conical portion 3 which communicates with the screw-thread portion 2. The internal diameter 4 is provided with a screw-thread 10 of an opposite hand—say a right-hand thread—to the screw-thread which is cut in the parallel portion of the diameter 2. In the internal diameter 4 is inserted the screw-threaded parallel portion 13 of the inner coupling-plug *b*. Between the plain and screw-threaded parallel portions 11 and 13 of the plug *b* is a hexagonal flanged portion 12. The plug *b* is also provided with a conical screw-threaded end 14. The inner coupling-plug *b* is of any suitable size and length, and it is made as just described, plain and parallel at its outer end—that is, the end furthest away from the outer coupling-box *a*. The portion 13 is provided with a screw-thread adapted to mesh with the right-hand screw-thread 10 of the internal portion 4, whilst the screw-thread 15 on the reduced conical end 14 is arranged to enter the hole *k* of the hose-pipe *e* for expanding purposes. The screw-threaded portion is provided with a lock-nut *g*, and on the outer end *h* of the portion 11 of the inner coupling plug *b* is mounted the ordinary union connection *c*, the outer end of the plug being suitably shaped and formed for retaining the union connection in position. In the drawings the means for retaining the union connection upon the outer end of the plug *b* is formed by reducing its diameter, and screwing a collar *i* thereon. The outer diameter of the collar *i* fits into the plain portion 18 of the recess 17 formed for its reception in the coupling *c*. By making the hole in the inner end of the coupling *c* slightly larger—say a sliding fit—than the diameter of the portion 11 of the inner coupling-plug *b*, a shoulder will be formed, against which the screwed collar *i* abuts. The inner and larger internal diameter of the coupling *c* is screw-threaded, as usual. The inner coupling-plug *b* is provided with a parallel central hole *j* which is slightly less than the hole *k* in the hose-pipe *e*, and the inner conical end of the plug is made to enter the hole *k* of the hose-pipe. The thickness of the metal of the conical inner end 14 is kept as thin as possible without forming a knife-edge. At a suitable distance from each end of the conical plug is cut or formed the screw-thread 15. The screw-thread is thus in the centre portion of the perimeter of the cone, so as to leave a plain portion at each end of the screw-thread. The hexagonal flange 12 is provided for turning purposes. *l* is a leather or other washer which is made to fit against the inner end *f* of the hose-pipe *e*. A number of air-holes *m* may be provided, if so desired, but not necessarily so, in the outer coupling *a*. (*Sealed.*)

14,999/15. W. Chadburn and W. R. Chadburn, Bournemouth. Speed-Indicators. [2 *Figs.*] February 8, 1915.—This invention relates to apparatus for indicating the number of movements made in a given division or interval of time by engines or other machinery or apparatus, such as the average rate of movement or the revolutions performed in such divisions or intervals of time, and wherein two or more pointers or indicators are employed and operate in conjunction with each other so as to indicate the rate of speed during the previous interval of time, as well as that of the period just completed; and this invention consists of a modification of the apparatus set out in the Specification No. 1989, of 1915. According to this invention, the two pointers employed each moves up from zero to a point which corresponds with the rate of speed of the engine or machine performed during the period or division of time in which it is so moving; and when one has reached this point it is held there, and the other is released, having been held, and flies back to zero; and it then commences to again move and count up from zero over the dial, and at a rate corresponding with that of the revolutions or movements of the engine or machine, finally indicating, say, the rate of revolutions or movements per minute; so that when either one or the other of the pointers is moving up from zero the other acts as a sentinel pointer, and stays at the division to which it has been moved in its action, representing the rate of movements or revolutions, say per minute, in the preceding period; and that one is released and flies back to zero when the other one in active movement has reached its limit of movement, and which is then held. 1 and 2 are the pointers or indicators, which are worked by the engine or machine it is desired to indicate the speed or movement of, and which move alternately from zero to various positions corresponding with the rate of speed of the engine or machine during the period of division of time in which it is so moving, and after which movement are held there, and after being so held are released and fly back to zero. The pointers 1 and 2 are fixed on the ends of inner and outer shafts 3 and 4, respectively, the latter tubular one being supported in the bearing 5, and the inner one being mounted at the back end in the bearing 6. Each of the pointers has connected with it a toothed wheel 8, one of which is mounted and fixed on the shaft 3, and the other is mounted and fixed on the shaft 4; and each of these wheels 8 has connected with it a holding and releasing pawl 9, which is operated at the required moments as hereinafter specified; and each wheel 8 has also connected with it a clutch device 10 consisting of two parts, one fixed to the wheel 8 and the other adapted to be moved into and out of engagement with the former, and driven from the motion transmission means of the instrument, operated from the engine





or machine the rate of which it is desired to indicate; and this movable part of each clutch device is moved longitudinally in one direction by a cam 11, and in the other by springs 12 put in compression by the action of the cam in disengaging this movable part from the other. The cams 11 are themselves revolved by a spring motor, the action of which is intermittent, and controlled by a timekeeping spring motor in the manner set out in Specification No. 1989/15. The pawls 9 are mounted on separate spindles on which are fixed the two lever-arms 13, which are operated by pins 15 on the disc 16. The driven part of each clutch is operated by a toothed wheel 17 on the shaft 18, which meshes with a toothed wheel 19 on each of the two clutch devices, and the shaft 18 is driven by the toothed gearing 21, which is operated through the main motion shaft 22 which transmits motion to the instrument, the bevel-wheels 23, and the shaft 22. In the alternate moving up from zero when the clutch 10 is put in engagement by the action of the cam 11, each pointer is revolved round its axis past the teeth of its wheel 8, and it will continue to revolve until, at the end of the selected time period, the cam 11 will move the longitudinally-movable part of the clutch device connected with the tooth-wheel 8 out of engagement with the same, when this wheel will stop and be held by its pawl 9 for a short period, and then it will be released by one of the tappet-pins 15 acting on the arm 13, which will throw the pawl 9 out of engagement with the wheel 8, and thereupon the spring 14 connected with this wheel—which will have been put under strain by its rotation—will bring it quickly back again to zero. This action takes place in each of the mechanisms of the two pointers. In the construction shown a "direction" pointer 0 is driven directly from the gear 23, 20 through the tooth-gear 24. The spring time-keeping motor mechanisms referred to may be assumed to be of the type set forth in the aforesaid Specification—that is to say, the periodical movements of the cams 11, tappet-pins 15, and the arms 13 and pawls 9 will be controlled by a time-keeping spring motor, which actuates an escapement mechanism, and the actuating cams, tappets, &c., are worked actually by another spring-motor mechanism when freed by the escapement mechanism operated by the first time-keeping spring motor. (*Sealed.*)